Instruments

THE MAGAZINE OF MEASUREMENT
INSPECTION · TESTING · CONTROL

ncluding the

JOURNAL OF THE INSTRUMENT SOCIETY OF AMERICA

nd the

JOURNAL OF THE SOUTHERN CALIFORNIA METER ASSOCIATION

n this issue . . .

Optimalizing Control

Refinery Control

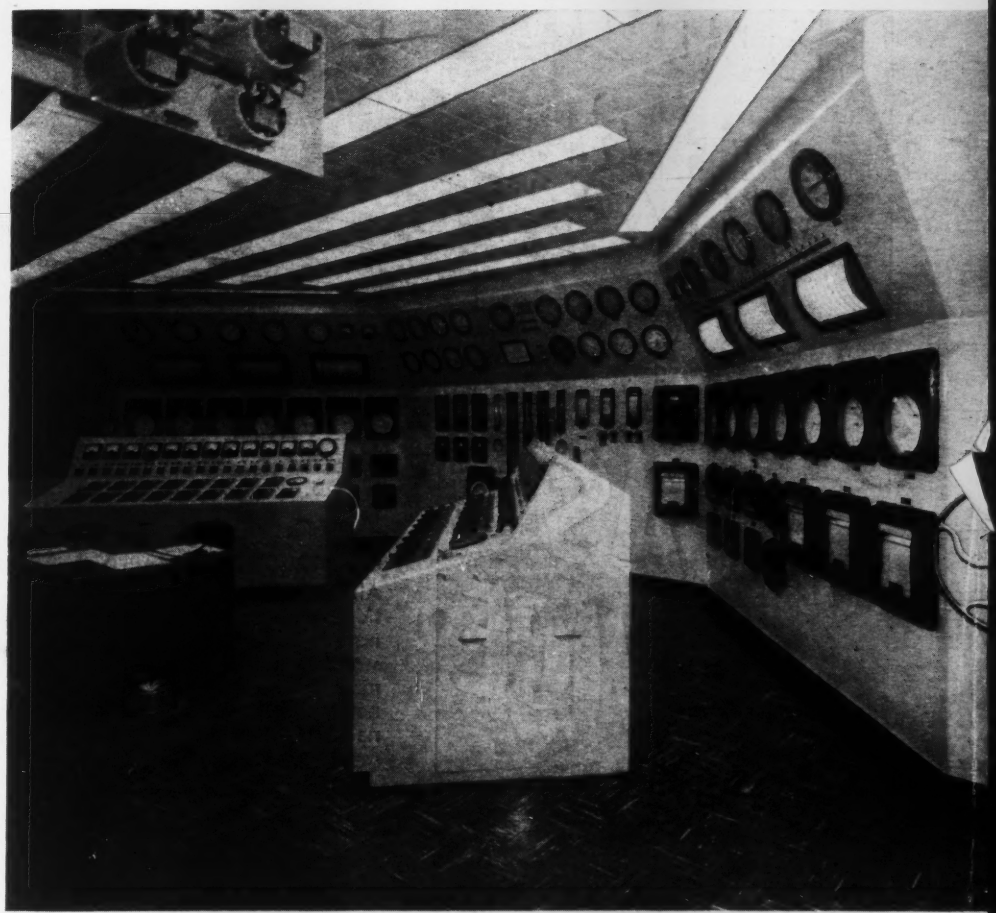
Instrument Electronics

Turbine Governors

Multi-element Control

55 New Instruments

93 New Bulletins Reviewed

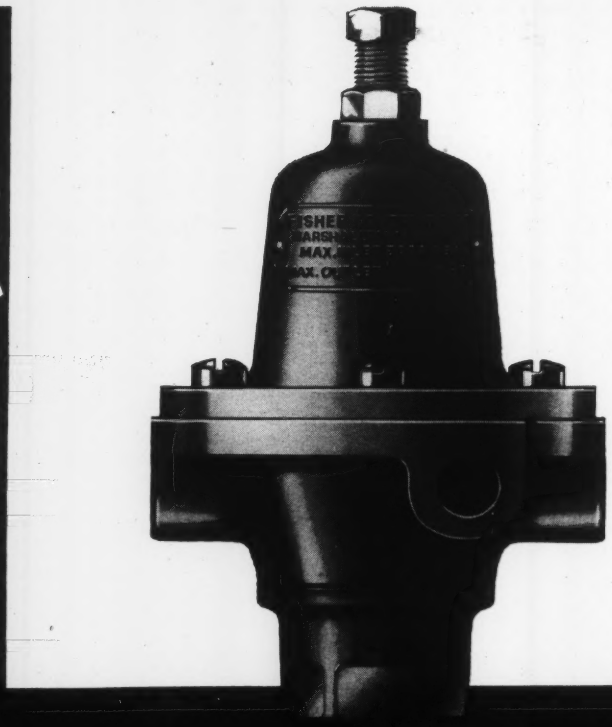


Centralized control room at the Mustang Station of the Oklahoma Gas & Electric Co., Oklahoma City, Oklahoma. *(Courtesy Bailey Meter Co.)*

. 25 No. 1

ANUARY • 1952

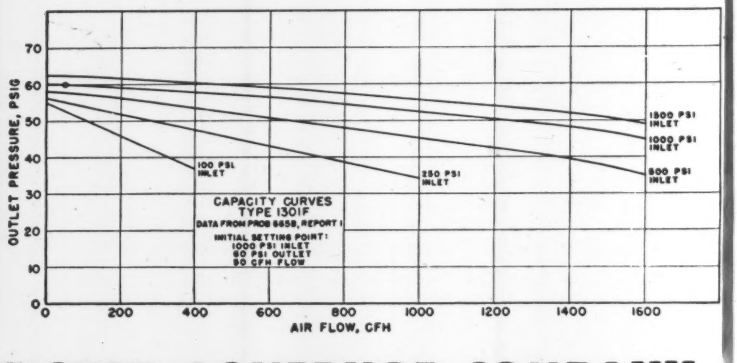
HIGH PRESSURE REDUCING VALVE for AIR or GAS SERVICE



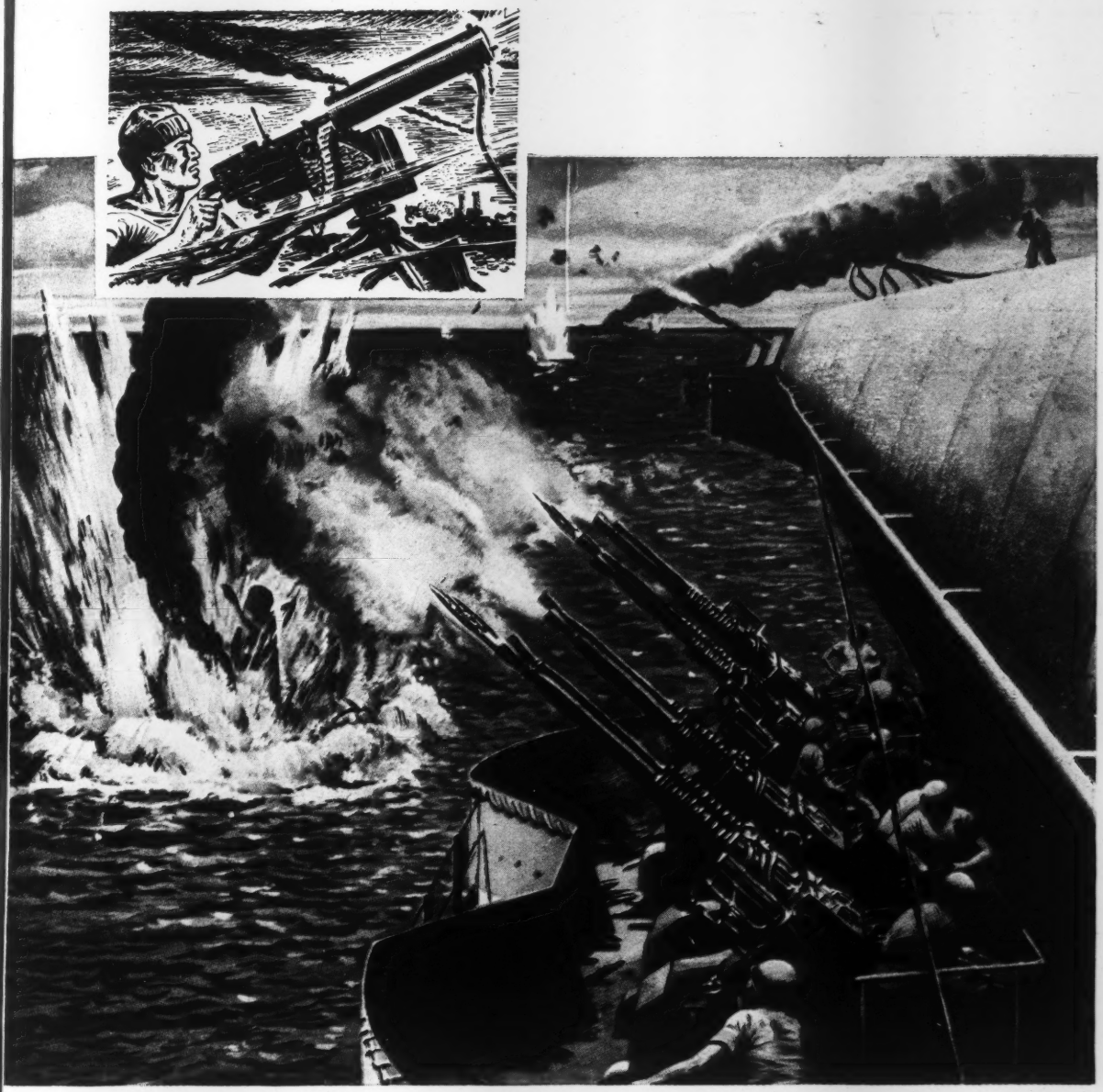
Type 1301F is commonly used in conjunction with pilot operated controllers where high pressure operating medium is used. They are also used in general industrial applications for high pressure reduction of non-corrosive air or gas.

CONSTRUCTION:
All forged bronze construction with glass impregnated Teflon valve disc, stainless steel orifice. Furnished with one inlet connection and two outlet connections of ¼" pipe size.

PRESSURE RANGE:
Suitable for inlet pressures up to 3000 PSI; reduced pressure spring ranges of 10 to 75 PSI; 50 to 150 PSI. Adjustment screw for easy adjustment of reduced pressure setting.



FISHER GOVERNOR COMPANY
Marshalltown, Iowa



Faster gunnery for our "flat-tops"— through electronics

Constantly faster and more accurate aerial attack upon aircraft carriers can only be answered in kind. Split-second gunnery is urgently demanded – and met through the miracles of electronics. Working closely with our Armed Forces for 33 years, Arma has developed the wealth of engineering experience and production techniques that plays an outstanding part in the production of these complex, compact, accurate instruments.

ARMA CORPORATION
254 36th Street, Brooklyn 32, N.Y.
SUBSIDIARY OF AMERICAN BOSCH CORPORATION

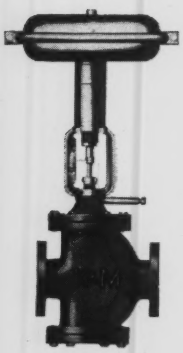
QUALITY ARMA INSTRUMENT PRECISION

Why Most Leading Companies Are Using K & M Control Valves

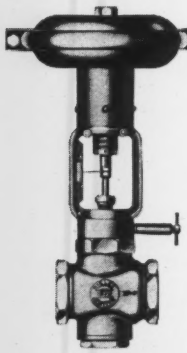
It is logical that leading companies should handle the important subject of control valves as they do other matters: They make use of the best available skills and thinking. More and more, they utilize the equipment, knowledge and facilities of the K & M engineering and service team.

Five years ago, K & M Advanced-Type Control Valves were new to industry. Today, with outstanding performance records behind them, K & M valves have become first in the regard of many instrument engineers. Increasingly, K & M representatives are called upon to give counsel and assistance in the planning of new control installations and the improvement of old ones. During the past year K & M men have been consulted on most of the projects in which control valves have been a major consideration.

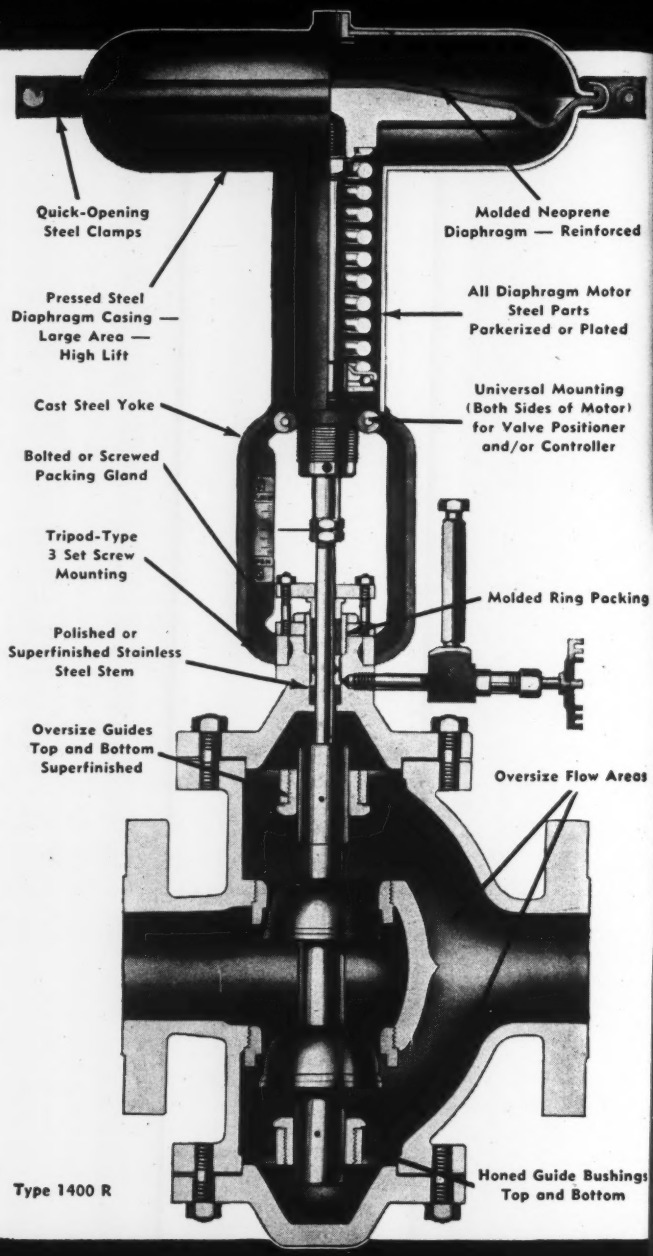
There is a qualified K & M representative near you, eager to discuss your problems and able to help you with them.



Type 1200



Type 1000


Quick-Opening Steel Clamps
Pressed Steel Diaphragm Casing — Large Area — High Lift
Cast Steel Yoke
Bolted or Screwed Packing Gland
Tripod-Type 3 Set Screw Mounting
Polished or Superfinished Stainless Steel Stem
Oversize Guides Top and Bottom Superfinished
Molded Neoprene Diaphragm — Reinforced
All Diaphragm Motor Steel Parts Parkerized or Plated
Universal Mounting (Both Sides of Motor) for Valve Positioner and/or Controller
Molded Ring Packing
Oversize Flow Areas
Honed Guide Bushings Top and Bottom

Type 1400 R

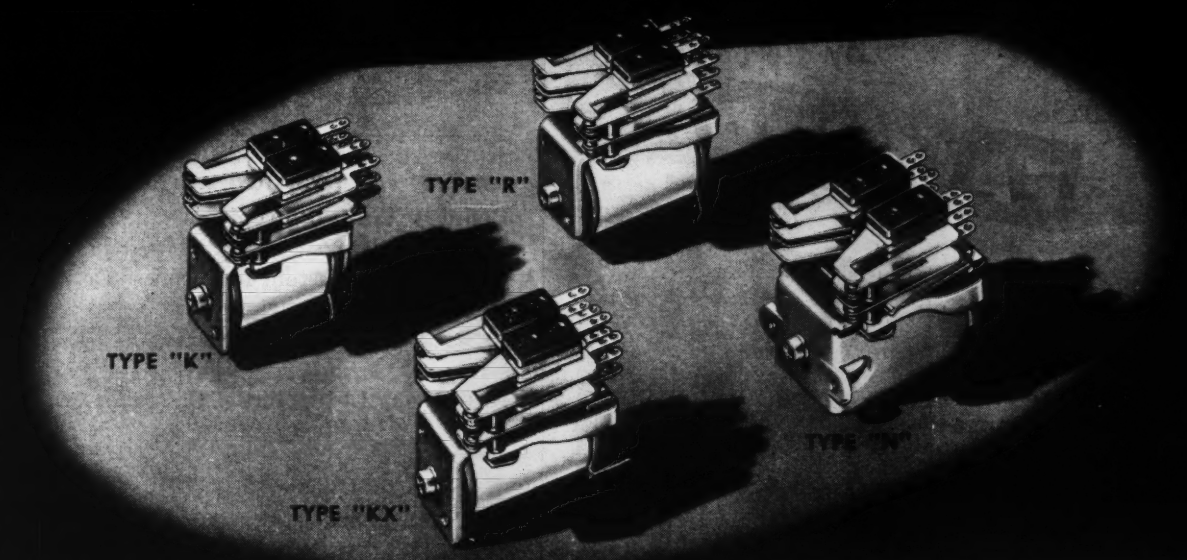
K&M

KIELEY & MUELLER, INC.

Valve Makers Since 1879

2017—43rd STREET NORTH BERGEN, N. J.

CLARE RELAYS



Special Features

which make these relays first choice of exacting design engineers

THE CLARE Type "K" RELAY

Fast operation—adequate contact pressure—high resistance to shock and vibration—long life—small size—1¼" x 1¼" x 1⁹⁄₁₆".

THE CLARE Type "KX" RELAY

Same features as Type "K" but adds greater operating range and increased sensitivity by use of a slightly longer coil which can be safely wound to a maximum resistance of 8000 ohms. Size: 1¾" x 1½" x 1".

THE CLARE Type "R" RELAY

Same basic features as Type "K" but adds still further sensitivity and operating range to the Type "KX" by the use of a coil which is not only longer but of increased diameter to provide even greater winding space. Size: 1¾" x 1⅝" x 1".

THE CLARE Type "N" RELAY

Same basic features as Type "K" but designed for operation on extremely low power. This results from a close-coupled magnetic circuit, generous use of magnetic iron and unusually efficient coil design. Size: 1⅝" x 1⅝" x 1⅛".

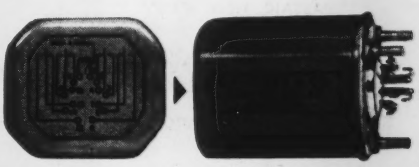
● The Clare Type "K" Relay was the first of the famous CLARE line of small, lightweight, telephone-type relays. It is still the mainstay of design engineers who must have superior relays to operate in extremely small space.

Its fast operation, adequate contact pressure, high resistance to shock and vibration, long life and complete all-around dependability have met many complex requirements.

The other three relays shown here supply all these advantages of the Type "K", but each adds certain other features to meet such specifications as a greater operating range, greater sensitivity or operation on extremely low power. All except the type "N" retain the reed armature suspension of special alloy which engineers recognize as one of the subtler reasons for the superior performance of these small CLARE Relays.

Clare sales engineers are located in principal cities to give you first hand information on the entire line of CLARE Relays . . . all of them designed to meet the most exacting relay requirements. Call them or write to C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable Address: CLARELAY.

All relays available in hermetically sealed form

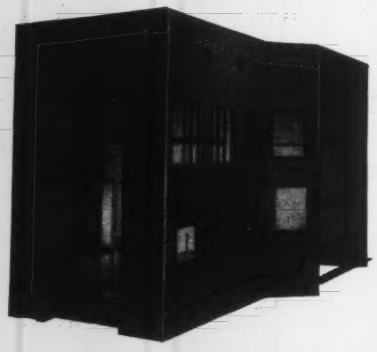


All of these four CLARE small relays are available enclosed in hermetically sealed steel containers. Connection diagrams are permanently imprinted on the base of the enclosure by silk screen process.

CLARE RELAYS

. . . First in the Industrial Field

Specify
CONTROL
PANELS
by
FALSTROM



COVER
CUBICLE
SECTION

-service on control panels is complete!

—FOR ALL PANELBOARD AND HOUSING REQUIREMENTS

You can depend on Falstrom for experienced design and expert workmanship in the building of panelboards, switchboards, cubicles, instrument panels, control centers and switchgear housings. Falstrom service includes the planning and production of distinctive, finished housings with functional qualities that assure practical economical installations. Check with Falstrom, now. Fill out and mail handy coupon for details.

FALSTROM COMPANY

92 FALSTROM COURT • PASSAIC, NEW JERSEY

Gentlemen:
I am interested in the items checked. Please send complete information at once.

NAME
TITLE
COMPANY
STREET ADDRESS
CITY ZONE STATE

☐ INSTRUMENT PANELS
☐ CHEMICAL BOARDS
☐ GAGE BOARDS
☐ CONTROL CENTERS

Instruments
THE MAGAZINE OF MEASUREMENT INSPECTION • TESTING • CONTROL

Vol. 25 JANUARY 1952 No. 1

TECHNICAL ARTICLES

Refinery Control Problems 70
By E. D. Mattix

Optimalizing System for Process Control 72
By Y. T. Li

SERIAL

Instrument Electronics 67
By Milton H. Aronson

INSTRUMENTS ON THE MARCH

Precision Thermostat 54

Electrodynamic VHF Ammeter 54

THE MONTH'S NEW INSTRUMENTS 32

OTHER REGULAR FEATURES

Editorial 31

Book Reviews 98

Manufacturers' Literature 104

Calendar of Important Instrumentation Events 113

Advertisers' Index 116

Index to Vol. 24 (1951) 61

JOURNAL of the
INSTRUMENT SOCIETY OF AMERICA 91

JOURNAL of the
SOUTHERN CALIFORNIA METER ASSOCIATION

Operating Experiences with Multi-element Control 101
By Howard L. Andersen

Copyright 1952 by The Instruments Publishing Company, Inc. Office of publication, 1600 North Main Street, Pontiac, Illinois. Executive and Editorial Office, 921 Ridge Avenue, Pittsburgh 12, Pennsylvania.

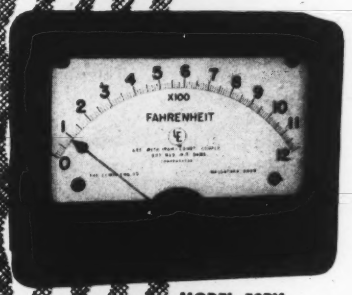
Entered as second class matter, October 14, 1949, at the post office at Pontiac, Illinois, under the act of March 3, 1879.

Continued on page 6

LEWIS INDICATING PYROMETERS

FOR TEMPERATURE TESTING IN THE LABORATORY OR IN THE PLANE . . .

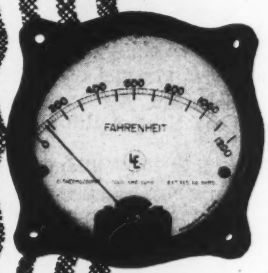
Constructed with the same care as our aircraft temperature indicators, these pyrometers bring "aircraft quality" to the test engineer. Use Lewis leads, thermocouples and selector switches to build complete temperature measuring installations. All models available with black dials and white markings for photographic observers.



MODEL 58PY

This instrument has been used extensively by the leading motor-car manufacturers for road testing on the "Proving Grounds" — where performance counts. Housed in a rectangular bakelite case, this reliable, fully compensated pyrometer is furnished with 6 in. hand drawn scales for greater accuracy. The Model 58PY is available for use with all standard thermocouple materials, in many ranges to suit the most exacting application.

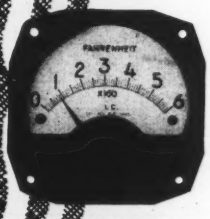
Accuracy — 1% of total scale deflection



MODEL 23B

Manufactured with the same type of movement as our aircraft pyrometers, the Model 23B pyrometer is well suited for use in moving vehicles and has been successfully used in many test stand installations. It is housed in a 4 in. round bakelite case that is flanged for panel mounting, and is available in several ranges for use with various thermocouple materials.

Accuracy — 2% of total scale deflection



MODEL 20B

The Model 20B series of indicators are patterned after our standard aircraft instruments and are supplied with 3" round steel cases suitable for panel installation. These compact, sturdy indicators have 2½ in. scales, are fully cold-end compensated and are available in many ranges for use with various thermocouple materials.

Accuracy — 2% of total scale deflection

STANDARD RANGES, ALL MODELS

FAHRENHEIT		*CENTIGRADE*	
0 to 400	0 to 1200	0 to 200	0 to 600
0 to 600	0 to 1600	0 to 300	0 to 800
0 to 800	0 to 1800	0 to 400	0 to 1000
0 to 1000	0 to 2000	0 to 500	0 to 1100
0 to 2500		0 to 1100	

THE LEWIS ENGINEERING CO.

Manufacturers of *Complete* Temperature Measuring Systems for Aircraft

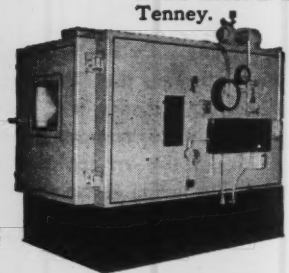
NAUGATUCK, CONNECTICUT

TEMPERATURES?
ATMOSPHERES?
PRESSURES?

for the finest in Test Chambers

TEST WITH Tenney

Tenney has combined years of specialized experience with the most advanced engineering methods. Results have convinced industry that Tenney testing equipment is the finest available. For complete confidence, specify Tenney.

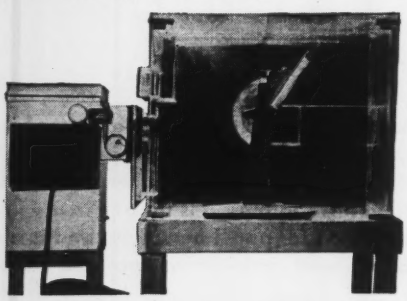


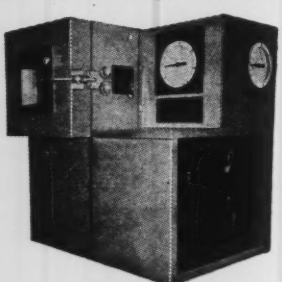
TENNEYZPHERE ALTITUDE CHAMBERS

Designed to withstand atmospheric pressure and to simulate global conditions of pressures, temperatures and humidities. Altitudes from sea level to approx. 75,000 ft. Temperature range from plus 200°F to minus 100°F. Also simulates desired relative humidity.

TENNEY SERVO UNIT

Portable air conditioning unit which may easily be attached to various types of laboratory enclosures—impact machines; tension machines; torsion testers; cold boxes and similar equipment. Through its use, articles undergoing testing, aging or weathering can be subjected to wide variations of humidity, heat and cold.



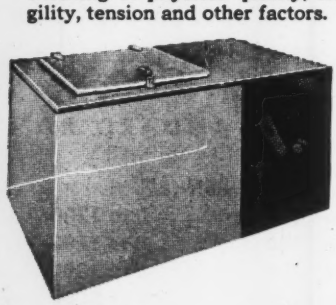


TENNEY TEMPERATURE AND HUMIDITY CHAMBER

Designed for positive control of temperature, humidity and air circulation. Permits the accurate checking of physical quality, fragility, tension and other factors.

TENNEY SUB-ARCTIC INDUSTRIAL CABINETS

Designed for low-temperature testing of metals, radios, instruments, plastics, liquids, chemicals and pharmaceuticals. Temperature ranges of −40°F, −60°F, −95°F and −150°F are standard for each size.



For further information on these and other Tenney test equipment, write to Tenney Engineering, Inc., Dept. B, 26 Avenue B, Newark 5, New Jersey.

Tenney

Engineers and Manufacturers of Automatic Temperature, Humidity and Pressure Control Equipment

7854

Instruments
THE MAGAZINE OF MEASUREMENT INSPECTION · TESTING · CONTROL

Published by

The Instruments Publishing Company
921 Ridge Avenue
Pittsburgh 12, Penna.

Richard Rimbach, *Publisher*
M. F. Behar, *Editor*
Milton H. Aronson, *Managing Editor*
James F. Emge, *Assistant Editor*

DISTRICT OFFICES AND MANAGERS

Altadena, Calif., M. D. Pugh, 2721 N. Marengo Ave., Telephone Sycamore 7-2894

Boston 14, James Condon, 133 Marlborough St., Telephone Commonwealth 6-5961

Chicago 1, Harold W. Haskett, Room 615, 360 N. Michigan Ave., Telephone Andover 3-4299

Cincinnati 5, Harold W. Haskett, 742 Elberon Ave., Telephone Grandview 4323

New York 17, Richard Rimbach, Jr., Room 349, 551 Fifth Ave., Telephone Murray Hill 2-0821

Philadelphia 40, William J. Gallagher, Room 1102, Beury Bldg., 3701 N. Broad St., Telephone Baldwin 9-9940

Pittsburgh 12, C. Goldcamp, 921 Ridge Ave., Telephone Fairfax 1-0161

St. Louis 1, James R. Wright, Stephen E. Wright, 411 N. 10th St., Telephone Chestnut 1965

London, W.C. 2, England. John C. N. Hughes, c/o T. G. Scott & Son, Ltd., 9 Arundel St., Telephone Temple Bar 1942

MEMBER
ABC
Audit Bureau of Circulation

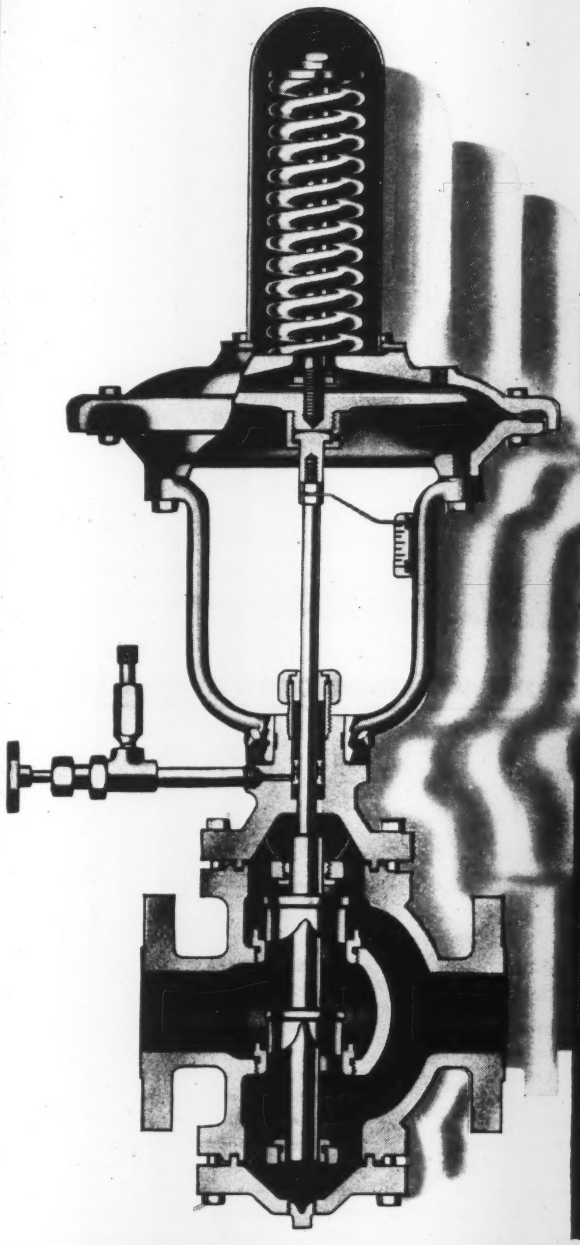
SUBSCRIPTION RATES
For One and Two Years.
United States, U. S. Possessions, and Canada $4.00, $7.00.
Latin America and Australia $5.00, $8.00.
All other countries except those noted below $6.00, $10.00.

For the present, subscriptions not accepted from Austria, Bulgaria, China, Czechoslovakia, Eastern Zone Germany, Hungary, India, Poland, Romania, Russia and Yugoslavia.

Payments from outside the U. S. A. must be in the form of an International Money Order or check on a U. S. bank.

Position and company connection as well as products manufactured must be indicated in all subscription orders.

LET 60,000 INSTALLATIONS GUIDE YOU TO BETTER PROPORTIONAL CONTROL



Optimum flow characteristics, coupled with free-floating, self-aligning motor action, have made "Stabilflo" the most preferred name in control valves. Ever since the development of proportional control, critical users have depended upon these wide-range V-port valves for the utmost in performance.

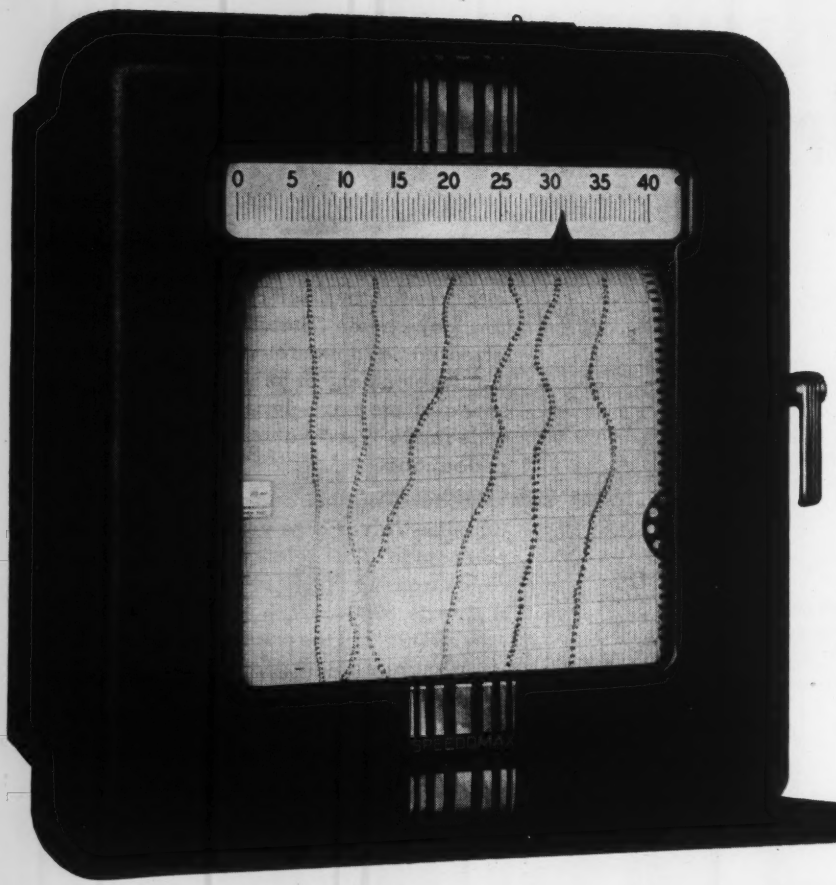
Because of their unique port design, Stabilflo Valves give very precise "equal percentage" flow relations throughout the range from 2 to 100% of flow. Their rangeability is 50-to-1. With these valves, you can be sure that the extraordinary sensitivity, accuracy and dependability of modern proportional controllers are translated into matching valve performance. Get the details in Bulletin 77-2. Write **The Foxboro Company, 161 Neponset Ave., Foxboro, Mass., U. S. A.**

Here is the [illegible] that gives Stabilflo Valves their unique equal percentage characteristic.

FOXBORO
REG. U. S. PAT. OFF.

STABILFLO CONTROL VALVES

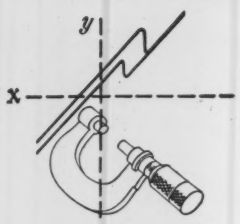
FACTORIES IN THE UNITED STATES, CANADA AND ENGLAND



NOW...

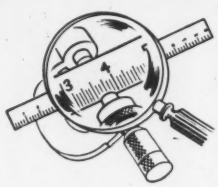
Multiple-point Speedomax recorder at left is a familiar sight in scientific laboratories throughout the world. While the 6 new instruments described below all *appear to be* practically identical, each *is different* from the others.

See how these 6 new Speedomax recorders



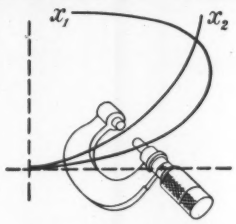
SPEEDOMAX X-Y RECORDER

Automatically plots the relationship between any two variables which can be converted to d.c. signals. Both pen and chart motion are reversible. Instrument records vacuum tube characteristics, hysteresis loops, stress-strain, temperature-elongation, differential thermal analysis curves . . . Applications are as broad as a researcher's imagination. *Write for Folder EM9-420(2).*



SPEEDOMAX ADJUSTABLE RANGE-ZERO RECORDER

Automatically plots voltage representing force, weight, temperature, temperature-difference, speed . . . or any other condition. Suppressing ZERO pushes *non-significant mv* off scale. Adjusting RANGE spreads few significant mv right across chart. Range *continuously* adjustable from —0.1 to +1 mv . . . up to —2 to +20 mv; zero suppression, from —50 to +50 mv. Folder ND46(2).



SPEEDOMAX 2-PEN RECORDER

Automatically plots 2 curves on 1 chart simultaneously . . . overlapping or side-by-side. Follows minute shifts in fast-changing variables with ease. A "2-in-1" recorder, it takes any *two* standard Speedomax ranges. Circuits work with thermocouples, Thermohms, strain gages, tachometers, thermal converters, pH cells . . . or most other primary elements. *Write for Folder EM9(1).*

For further information and application data on any Speedomax electronic recorders, just write our nearest office or 4907 Stenton Ave., Phila. 44, Pa.

LEEDS &

Jrl. Ad. ND46(5)

SPEEDOMAX presents

6 precision electronic servants to speed plotting of test data

AS the tempo and complexity of today's research and engineering activities accelerate, more and more investigators are stepping up efficiency through use of time-saving Speedomax recorders. Tireless automatic assistants, these electronic servants are taking over the chores of routine computation . . . eliminating tedious manual plotting of data.

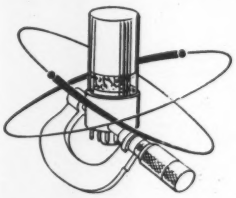
Especially timely are these 6 new Speedomax recorders developed specifically for laboratory use. While each is a *specialist*, it is also designed for a diversity of applications.

Common denominators for all six are traditional Speedomax precision and high-speed response. Recording pens can whip across the 9⅞" chart in as little as *1 second*, if the application demands, though speeds of 2 and 3 seconds full scale are also available. Balancing is velocity-damped to take advantage of this high speed.

Alert to the most minute variation in "X," the sensitive electronic balancing system is the perfect complement for the instrument's accurate null-balance measuring circuit. Thorough filtering, shielding and guarding screen out transients . . . permit use of Speedomax in the presence of severe stray fields.

Net result: the investigator can follow complex, fast-changing variables with ease and confidence . . . knowing that the record on his Speedomax is faithfully following the actual function being measured.

can solve your data-logging problems . . .



SPEEDOMAX PHOTOMULTIPLIER TUBE RECORDER

Automatically plots accurate record of light intensity or other low level radiation. Can be direct-connected to photo-multiplier tubes . . . eliminating separate preamplifier. Available by switch are four ranges: 0.02, 0.06, 0.2, and 0.6 μs. Dark current or noise of photo-multiplier tube is readily offset by built-in manual compensator. *Write for DS-240-70-EM9(1) to (3).*

SPEEDOMAX POWER LEVEL RECORDER

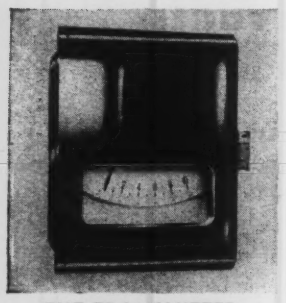
Automatically plots radiation patterns of antennas and hydrophones . . . frequency characteristics of filters, amplifiers, loudspeakers, etc. Applies accurate "insertion loss" principle of measurement. Recorder can be supplied with full scale reading of 20, 30, 40, 50, or 60 db, referred to a base level of as little as 0.02 microwatt. *Write for Folder ND46-51(1).*

SPEEDOMAX PRECISION THERMOMETER RECORDER

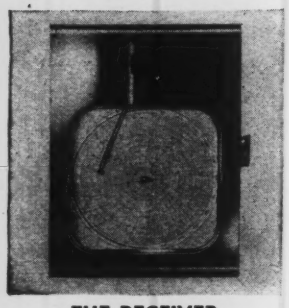
Automatically plots temperature curves for calorimetry, freezing and boiling points . . . reads resistance of platinum thermometer to five significant figures. An "automatic Mueller Bridge," it covers the entire range from —260 to +500 C with precision of ±0.01 C. Automatic range-changing mechanism expands chart width 100 times. *Write for Folder ND46-33-240(1).*

NORTHRUP CO. 40 years of precision recording 20 years of electronic recording

HOW TO SIMPLIFY PROBLEMS OF REMOTE MEASUREMENT AND CONTROL



THE TRANSMITTER



THE RECEIVER

Bristol Metameter* Telemetering Instruments Help Step Up Production... Save Time and Money... by Remote Measurement and Control of Pressure, Water Level, Flow, Temperature, Motion, Voltage, Current, Power and Totalized Load.

The Bristol Metameter Telemeter consists of three unit parts: Transmitter, Receiver, and interconnecting line which provides the electrical circuit between the two instruments.

The Transmitter is located close to the point of measurement. Its function is to transmit the readings to the receiver which can be any distance from a few feet to many miles away.

Readings can be transmitted over any two-wire circuit or its equivalent. Private wires, telephone circuits, radio (including microwave), or carrier current channels can be used.

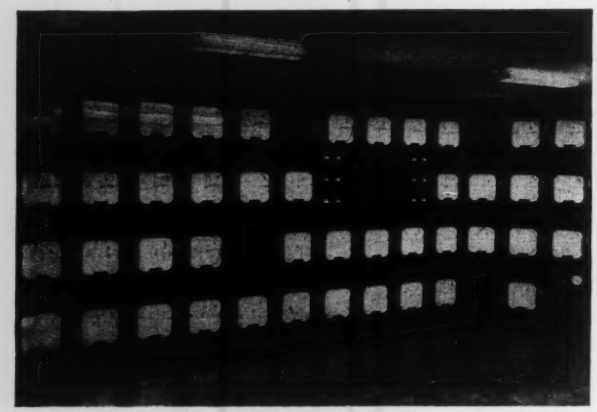
THE TRIED AND PROVED TELEMETERING SYSTEM. Bristol Metameter Telemeter is the product of 37 years of pioneering research and development work. Bristol's continuous program of engineering research and development keeps the Metameter abreast of modern requirements, making it the most reliable and widely used instrument in the field of telemetering.

A few of the thousands of Bristol Metameter Telemeter users:

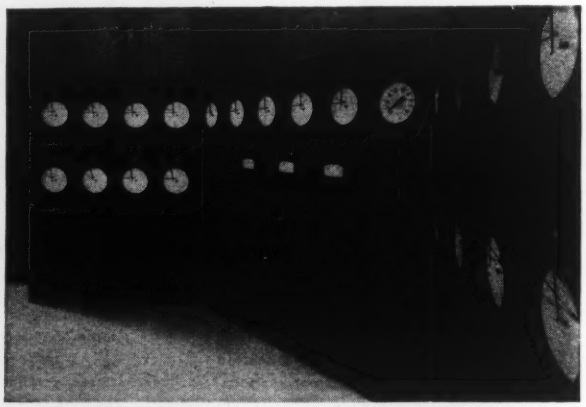
Standard Oil (Indiana), Flintkote, Jones & Laughlin Steel, Bethlehem Steel, Corn Products Refining Company, Champion Paper & Fibre, Mathieson Chemical, New York Central System, McCarthy Chemical, Weirton Steel, Eastman Kodak, United Piece Dye Works, Freeport Sulphur, U. S. Weather Bureau, Bonneville Power Administration, Woodward Iron, Celanese Corporation, Anaconda Copper.

*Reg. U.S. Pat. Off.

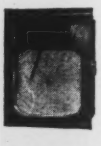
WRITE US FOR BULLETIN M1700. THE BRISTOL COMPANY 113 BRISTOL ROAD, WATERBURY 20, CONN.



UNITED STATES STEEL COMPANY These Recording Metameter Receivers provide fuel dispatcher with information concerning gas fuel supply and demand throughout plant at Gary, Ind., help maintain highest production of steel with lowest fuel cost.



AT THE FORD PLANT Metameter Receivers used by the Ford Motor Company in dispatching gas throughout its Dearborn plant, bring readings of pressure and flow to central point for use of dispatchers. This installation has been in operation since 1936.



BRISTOL

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

TRADE MARK

REG. U. S. PAT. OFF.

Presenting

a NEW MARK of Long-Established Quality

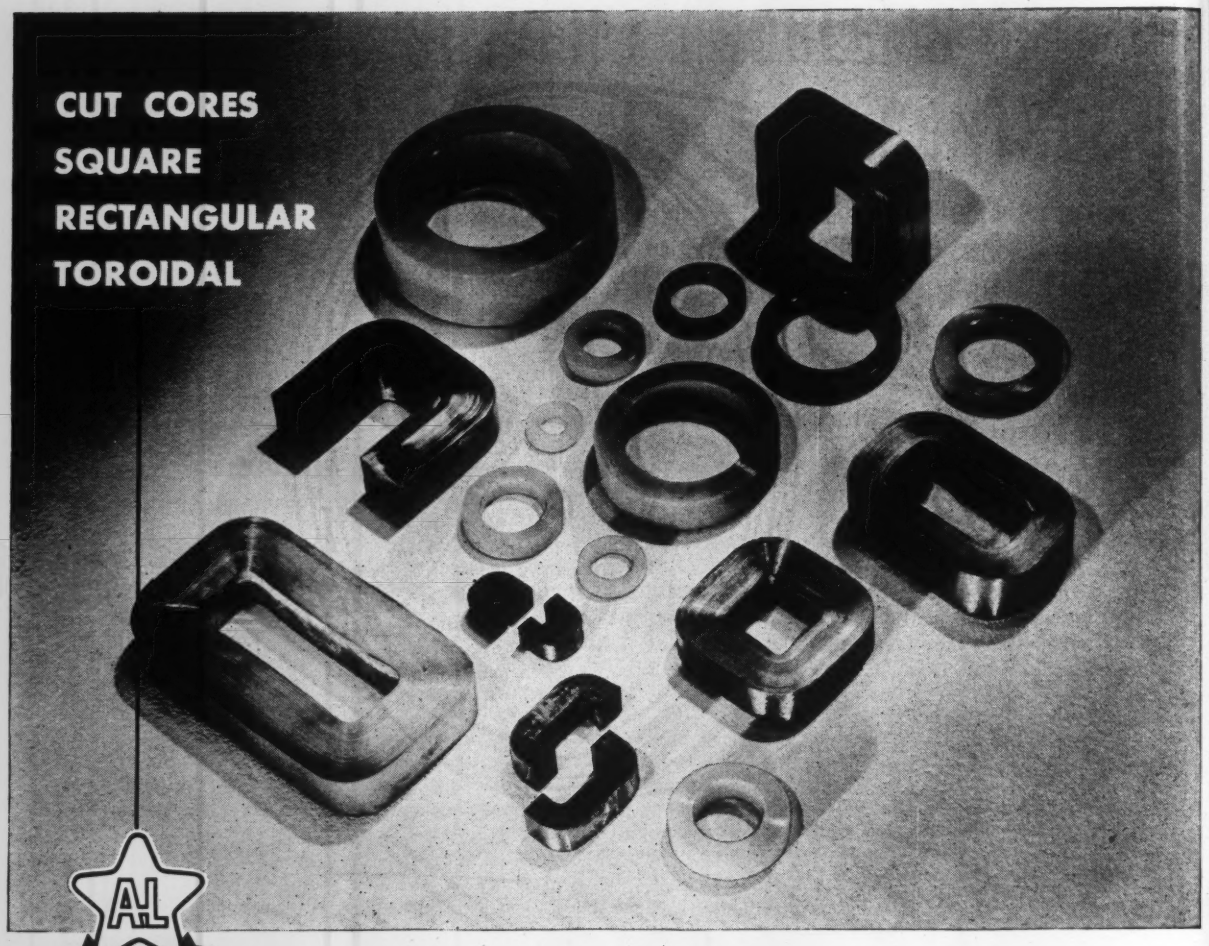
Since 1878 and the earliest bicycle cyclometer . . . to the present day when counters are built into everything from hay-balers and textile looms to jet planes and gasoline pumps . . . Veeder-Root has been "the name that counts."

Today, Veeder-Root is the world's largest manufacturer of counting and computing devices for mechanical, electrical, and manual operation. And as a symbol of "the name that counts," this trademark has been developed as a hallmark of old-fashioned quality and modern design *in everything that counts.*

So when you buy counters. look for this mark, and remember: V-R stands for Veeder-Root . . . and also for *"Value Received."*

VEEDER-ROOT INCORPORATED
"The Name That Counts"
HARTFORD 2, CONN. • GREENVILLE, S. C.
Montreal, Canada • Dundee, Scotland
Offices and agents in principal cities

Veeder-Root COUNTERS *"Count Everything on Earth"*



Anything You May Need in TAPE-WOUND CORES

RANGE OF MATERIALS

Depending upon the specific properties required by the application, Arnold Tape-Wound Cores are available made of DELTAMAX . . . 4-79 MO-PERMALLOY . . . SUPERMALLOY . . . MUMETAL . . . 4750 ELECTRICAL METAL . . . or SELECTRON (grain-oriented silicon steel).

RANGE OF SIZES

Practically any size Tape-Wound Core can be supplied, from a fraction of a gram to several hundred pounds in weight. Toroidal cores are available in fifteen standard sizes with protective nylon cases. Special sizes of toroidal cores—and all cut cores, square or rectangular cores—are manufactured to meet your individual requirements.

RANGE OF TYPES

In each of the magnetic materials named, Arnold Tape-Wound Cores are produced in the following standard tape thicknesses: .012", .008", .004", .002", .001", .0005", or .00025", as required.

Applications

MAGNETIC AMPLIFIERS
PULSE TRANSFORMERS
CURRENT TRANSFORMERS
WIDE-BAND TRANSFORMERS
NON-LINEAR RETARD COILS
PEAKING STRIPS . . . REACTORS.

WAD 3963

THE ARNOLD ENGINEERING COMPANY

SUBSIDIARY OF ALLEGHENY LUDLUM STEEL CORPORATION
General Office & Plant: Marengo, Illinois

Here's why it pays to know your HSM

HONEYWELL SUPPLIES MAN

This butt-welded thermocouple is faster because: (1) Butt-welding replaces mass of metal at hot junction; (2) Shape of wire prevents insulator from dissipating heat and affecting response.

J. F. KRAMER, Honeywell Supplies Man in the Cleveland area, tells Mr. George Taylor of the S. K. Wellman Co. all about the new Brown butt-welded thermocouple . . . after describing the benefits of the HSM Plan for buying pyrometer supplies.

You'll be pleasantly surprised when *you learn* how *the plan* can add new convenience and economy to your pyrometer supplies purchasing, too!

There's a Honeywell Supplies Man near you . . . at your local Honeywell office . . . no further away than your phone. Call him in today, and you'll take an easy step in the right direction.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4482 Wayne Ave., Philadelphia 44, Pa. Stocking points in Philadelphia, Cleveland, Chicago, Atlanta, Houston, Los Angeles and San Francisco.

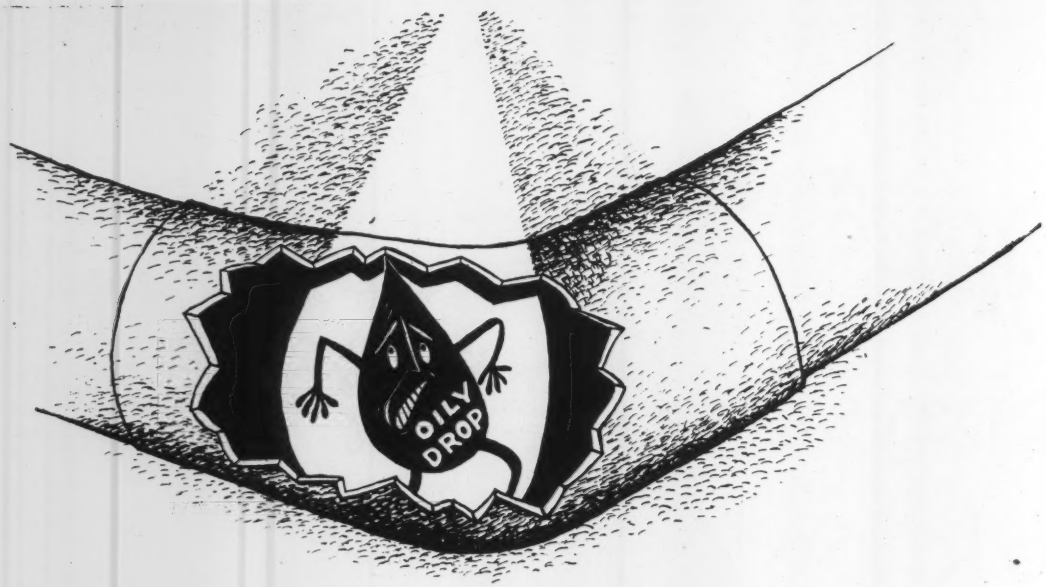
MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

● *Important Reference Data*

Write for Specification Sheet No. 306 on the butt-welded thermocouple . . . and for new Pyrometer Supplies Buyers' Guide No. 100-4.



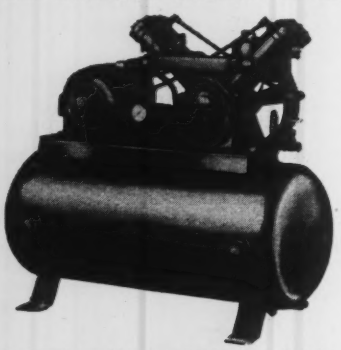
spotlighting a different kind of saboteur in vital instrument lines!

Oil-laden air can knock out your air-operated instruments . . . just as effectively as a "fifth columnist" can! When a slug of oil hits, you know what it can mean in production losses and excessive maintenance. That's why you'll be interested in this news about an easy, economical way to eliminate oil in instrument lines:

Ingersoll-Rand has engineered special air compressors that deliver *oil-free* air. These I-R Compressors feature pistons fitted with patented, graphitic carbon rings. The rings prevent metallic contact of the piston with the cylinder bore. The carbon rings are segmental with metallic inner expanding rings to give the proper wall pressure. Because metallic contact is eliminated, and the rings are self-lubricating, the Ingersoll-Rand NL Compressor cylinders require no lubricant.

If oil-laden air has *ever* caused you trouble, Ingersoll-Rand has engineering facts and figures that will interest you. Just contact your nearest I-R representative, or write direct to Ingersoll-Rand, 11 Broadway, New York 4, New York.

676-3

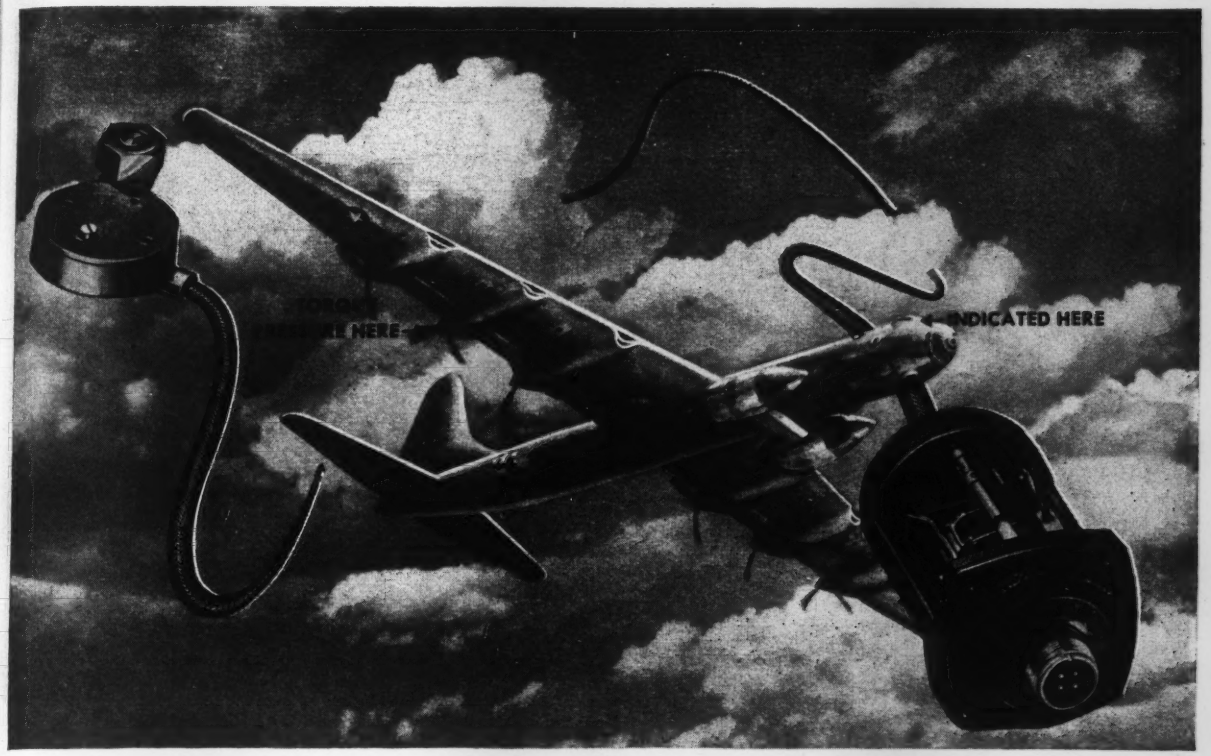


Model N machines available through 1 hp.
Model 235 HNL machines available through 3 hp—other models through 250 hp.

Ingersoll-Rand

NL COMPRESSORS

70 years of compressor "know-how" packed into these new compressors for air operated instruments



A NEW APPROACH IN AIRCRAFT TORQUE PRESSURE INSTRUMENTATION

Provides complete freedom from the attacks of sand, dust, fungus, salt fog and humidity

LOOK AT THESE EXCITING "FIRSTS" . . .

- Hermetically sealed and helium protected pressure and electrical elements.
- Nispan "C" pressure elements eliminating bimetallic compensation.
- Higher precision in remote transmission.
- Smaller and lighter in weight with tear-strip ease of disassembly.
- External adjustment through hermetic seal.
- Isolating link and pressure pick up for temperature extremes of —85 and +230 F.

In this Synchro Torque Pressure Transmitter one element measures the pressure and the other the ambient outside pressure. Together, these two Nispan elements measure the applied pressure in a sealed case charged with an inert gas, and transmit an electrical signal through a glass-to-metal connector.

This refreshing solution to a difficult problem leads a whole flight of new direct-connected clamp-on pressure indicators for oil, fuel, manifold, and hydraulic pressures.

United States Gauge, Division of American Machine and Metals, Inc., Sellersville, Pa.

USG
Oil Pressure Gauge

USG
Fuel Pressure Gauge

USG
Manifold
Pressure Gauge

USG
Hydraulic
Pressure Gauge

Quality Gauges Engineered for Enduring Accuracy

USG

PRODUCTS OF UNITED STATES GAUGE . . . Absolute Pressure Gauges • Aircraft Instruments • Air Volume Controls • Altitude Gauges • Boiler Gauges Chemical Gauges • Mercury, Gas, and Vapor Dial Thermometers • Glass Tube and Industrial Thermometers • Flow Meters • Inspectors' Test Gauges Precision Laboratory Test Gauges • Marine, Ship and Air-Brake Gauges • Voltmeters • Ammeters • Welding Gauges

OTHER DIVISIONS OF AMERICAN MACHINE AND METALS, INC., AT SELLERSVILLE, PA.: GOTHAM INSTRUMENTS AND AUTOBAR SYSTEMS

Main Panel Board for control of 3000 bbl per day Kiln at Missouri Portland Cement Company, St. Louis, Missouri.

3 Ways Better

...Bailey Control for Rotary Kilns

Bailey Control for Rotary Kilns gives you better performance three ways:

1. Economical Operation
2. Uniform Quality of Product
3. Reduced Maintenance

These are advantages which can be achieved when all phases of kiln operation are coordinated to work together as a team. Here's how Bailey Kiln Control can help you get all three.

ECONOMICAL OPERATION

With Bailey Combustion Control you can be certain that you are getting maximum product for every unit of fuel you burn. Bailey Control closely guards the Fuel-Air Ratio, Hood Draft, Fuel Feed, Clinker Cooling and the Temperature of Air for Combustion.

UNIFORM QUALITY OF PRODUCT

Bailey Instruments and Controls can help you achieve a uniform high grade product. Measurements of temperatures, kiln speed, combustibles content, and oxygen content can be transmitted to recorders on centrally located control boards like the one shown. There is no sacrifice of accuracy or speed of response. High temperature alarm contacts may also be provided with Bailey Pyrometers as a further aid in achieving optimum uniformity of product.

REDUCED MAINTENANCE

By maintaining uniform temperatures and excess air conditions in the kiln, Bailey Controls help to reduce to a minimum costly refractory repairs and wear and tear on auxiliary equipment.

Bailey Meter Company has a staff of engineers who are experts in the control of rotary kilns. Assure yourself of optimum kiln performance. Let one of these men help plan your Kiln Control System. P-22

BAILEY METER COMPANY

1041 IVANHOE ROAD • • • CLEVELAND 10, OHIO

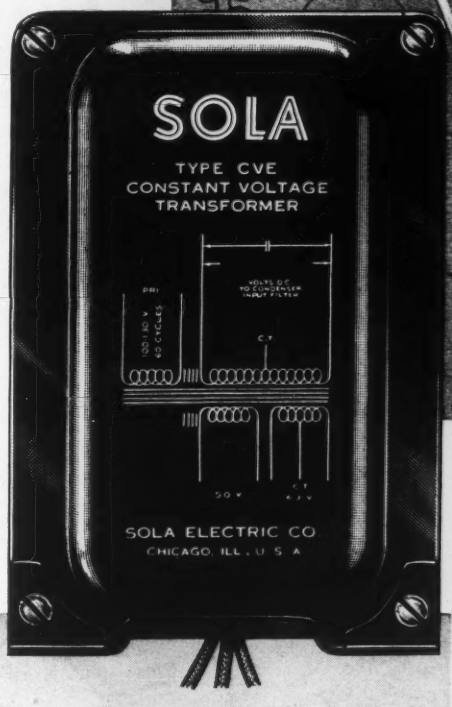
Controls for Processing

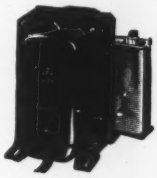
TEMPERATURE FLOW
PRESSURE LEVEL
% OXYGEN DENSITY
% COMBUSTION RATIO

Built-in VOLTAGE REGULATION *at Moderate Cost*

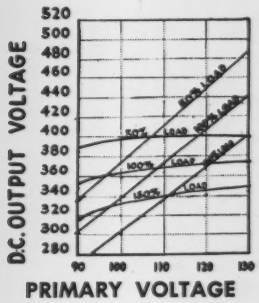
Insure constant plate and filament voltage for your electronic products with standard SOLA "CVE" POWER TRANSFORMERS.

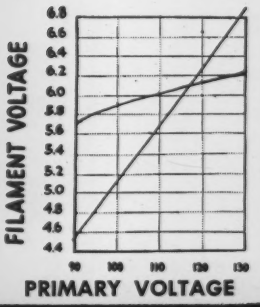
Specify the new SOLA "CVE" Constant Voltage Power Transformers in your circuit design to eliminate the variable of fluctuating line voltage at unusually low cost. Regulation of filament and plate supply is ±3% at line voltage variations from 100 volts to 130 volts.





REGULATION COMPARISON
SOLA "CVE" Power Transformer—
Typical Ordinary Power Transformer—

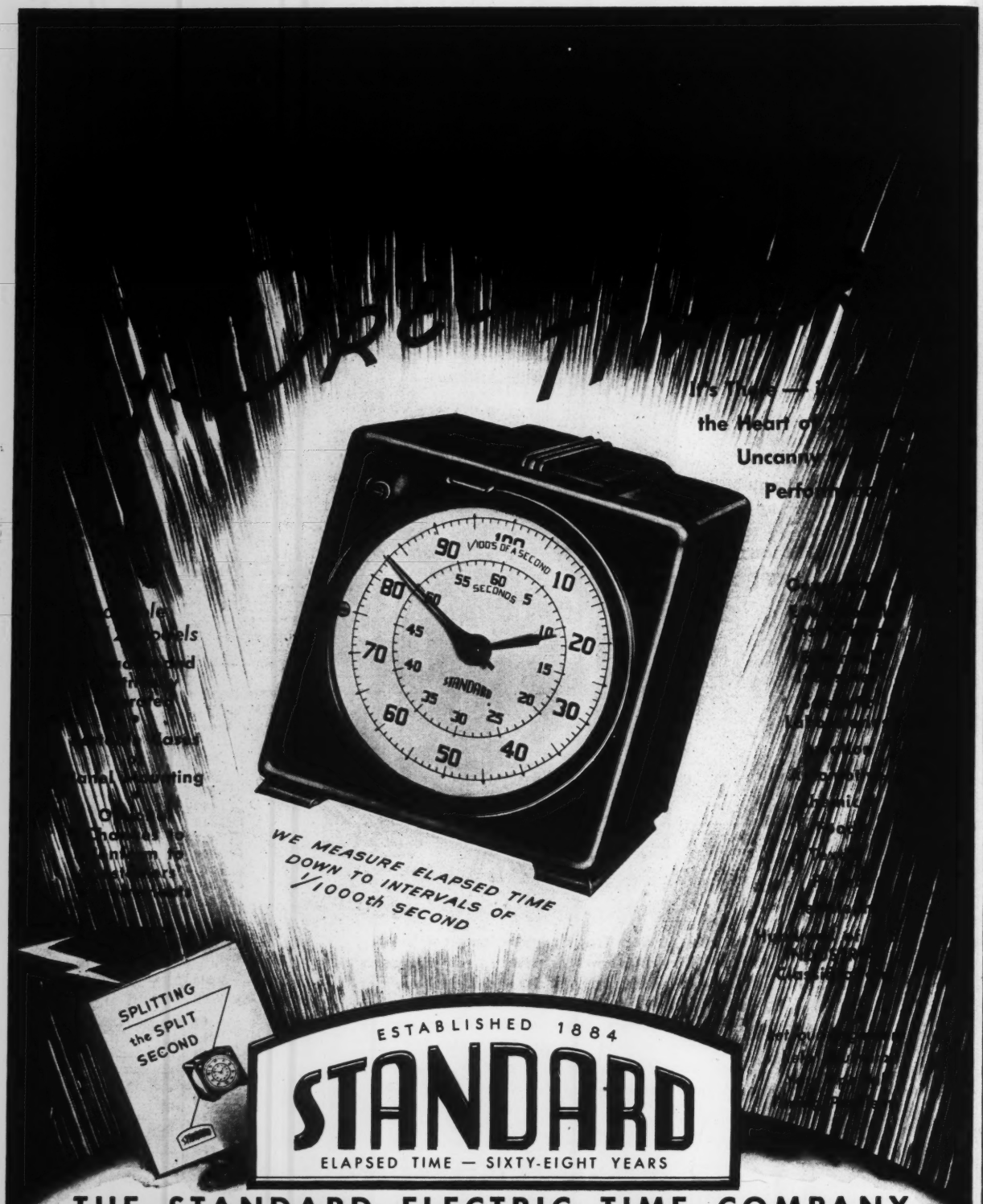




The SOLA "CVE" standard Power Transformers are completely automatic and continuous in regulation . . . have no moving parts or tubes . . . and are self-protecting against short circuit. They are stocked in 42 V.A., 75 V.A. and 210 V.A. capacities to cover most electronic power supply requirements. We invite your inquiries on the application and benefits of the moderately priced "CVE" Constant Voltage Power Transformers to your product. For full electrical and mechanical specifications write for Bulletin G-CVE-138.

SOLA *Constant Voltage* TRANSFORMERS

"CV" for high precision voltage regulation. "CVE" for regulated electronic power supplies. "CVH" for constant voltage with less than 3% harmonic distortion. "CVA" for constant voltage on television receivers.


WE MEASURE ELAPSED TIME
DOWN TO INTERVALS OF
1/1000th SECOND
SPLITTING
the SPLIT
SECOND
ESTABLISHED 1884
STANDARD
ELAPSED TIME — SIXTY-EIGHT YEARS
THE STANDARD ELECTRIC TIME COMPANY
93 Logan Street, Springfield 2, Massachusetts
TIMERS AND CHRONO-TACHOMETERS
LABORATORY PANELS
PROGRAM CLOCK SYSTEMS
PIPELINE ANALYZERS

Specify **CHESTER**

plasticord-plasticote

WIRES and CABLES

JAN-C-76 WIRES SRIR* SRRF* SRHV* WL*

80°-90° 105°C UL APPROVED WIRES*

SHIELDED WIRES and CABLES

FLEXIBLE CORDS

TELEVISION LEAD-IN WIRES

COMMUNICATION WIRES and CABLES

COAXIAL CABLE

INSTRUMENT WIRES

WIRES and CABLES to SPECIFICATION

*Solid Colors or Spiral Marking

Everything in wiring

More and more—engineers, designers, production men and purchasing officials have come to regard Plasticord and Plasticote Wires and Cables by Chester as the standard of comparison. This is because every inch of these dependable insulated conductors is made to conform to exacting quality controls that assure long service life, and performance as specified by the factory. That's the reason electrical men, everywhere, look for the Chester trademark when they're looking for the best!

"Chesty" says—

Our new catalog is a complete guide to plastic insulated wire and cable for every purpose. Write for a copy of this important data compilation for your files today.

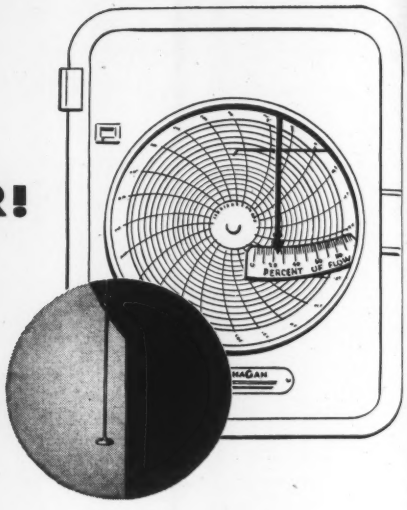
CHESTER CABLE CORP.

CHESTER, NEW YORK

MANUFACTURERS OF QUALITY WIRES AND CABLES FOR EVERY REQUIREMENT

One man can check a

HAGAN RING BALANCE METER!



He needs only a handful of check weights!

The check weight system for checking HAGAN *Ring Balance Meters is:*

The calibrated check weights supplied with each meter are stamped with the equivalent in inches of water differential. An easy calculation gives the relation between differential pressure and meter reading.

Here is all you do to check a Hagan Ring Balance Meter:

1. **Simply close one shutoff valve and open the equalizing valve**
2. **Check for zero**
3. **Put check weights on ring assembly**
4. **Read pointer or pen position.**

Checking the Hagan Meter minimizes meter outage time. Sounds easy? It's just as easy as it sounds.

★ **ACCURATE**—check the Hagan Ring Balance Meter under full static pressure.

★ **CONVENIENT**—a handful of check weights does the trick—no cumbersome equipment.

★ **TIME—AND MONEY-SAVING**—only one man is needed, and he can check the Hagan Meter in a very few minutes.

For information about Hagan Ring Balance Meters and how they can work for you, write to Hagan Corporation, Hagan Building, Pittsburgh 30, Pa.

HAGAN CORPORATION

RING BALANCE FLOW AND PRESSURE INSTRUMENTS
THRUSTORQ FORCE MEASURING DEVICES
BOILER COMBUSTION CONTROL SYSTEMS
METALLURGICAL FURNACE CONTROL SYSTEMS

HAGAN
HALL
BUROMIN
CALGON

Hagan Corporation
Hagan Building
Pittsburgh 30, Pennsylvania

Please send me further information on Hagan Ring Balance Meters. I am particularly interested in.....

.....

NAME.....

POSITION.....

COMPANY.....

STREET AND NUMBER.....

CITY..... ZONE..... STATE.....

I-1

Precise temperature control by Niagara Aero Heat Exchangers achieved by Multi-Purpose Thermostat

Fenwal THERMOSWITCH thermostat controls spray water temperature by admitting steam to steam injector — or turning on electric immersion heater to heat spray water.

These exchangers are particularly useful in chemical processes or in cooling quench baths during heat-treating of metals because their constant temperature assures uniform rate and quality in production.

One of the key points in the operation of Niagara Aero Heat Exchangers is precise temperature control of spray water.

To make sure of positive temperature control at all times, Niagara relies on a Fenwal THERMOSWITCH thermostat. This unique, low-cost unit prevents temperature of spray water from dropping below a given point by controlling steam injector or electric immersion heater which supplies additional heat. It also starts the spray pump motor.

These easy-to-install, easy-to-maintain Fenwal THERMOSWITCH thermostats are used to solve all types of control problems. Their activating control element is the single-metal shell that expands or contracts *instantaneously* with temperature changes, making or breaking the totally enclosed electrical contacts.

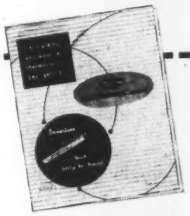
Find out now how Fenwal THERMOSWITCH units can help you. They effectively control many variables where heat is a factor. Mail coupon below for further information.

Fenwal

THERMOSWITCH

The Precision, Multi-Purpose, Thermostat Control

SENSITIVE . . . *but only to heat*



FREE! **Get this bulletin . . . see what Fenwal THERMOSWITCH Units can do for you.**

Just fill in coupon and mail . . . no obligation.

FENWAL, INCORPORATED, 171 Pleasant St., Ashland, Mass.
Los Angeles, Cal.

TEMPERATURE CONTROL ENGINEERS

Name ..... Position .....

Company .....

Street .....

City ..... Zone ..... State .....

I am chiefly interested in the applications checked:

- ☐ Heating
- ☐ Cooling
- ☐ Humidity Control or Detection
- ☐ Alarm (over-temperature, under-temperature)
- ☐ Vapor Control
- ☐ Timing (thermal)
- ☐ Radiant Heat Control
- ☐ Pressure Control (by controlling vapor temperature)

OTHER (Please fill in your special requirements) .....

.....

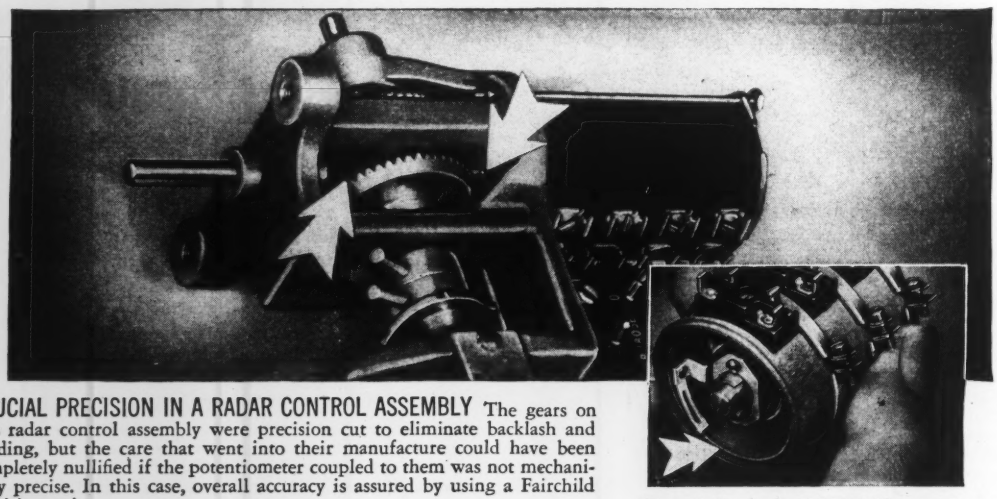
.....

Where mechanical precision means electrical accuracy

There's more to a precision potentiometer than accurate windings. In order that the required high *electrical* tolerances be held, it is absolutely essential that such parts as the shaft, mounting plate, and housing be designed and built for highest *mechanical* accuracy.

At Fairchild, we've concentrated on building precision equipment of all kinds for more than thirty years. Our engineers and craftsmen eat, drink, and sleep precision. Since our first potentiometer was produced, we've made it a practice to carefully control every phase of manufacture by building in our own plant every part that affects accuracy.

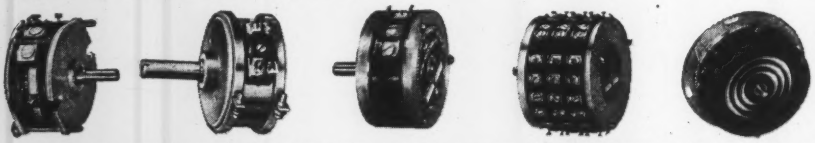
The example below is but one case of how this extra mechanical precision assures highest electrical accuracy.



CRUCIAL PRECISION IN A RADAR CONTROL ASSEMBLY The gears on this radar control assembly were precision cut to eliminate backlash and binding, but the care that went into their manufacture could have been completely nullified if the potentiometer coupled to them was not mechanically precise. In this case, overall accuracy is assured by using a Fairchild precision unit.

Like all Fairchild potentiometers, this one has a shaft that is centerless ground from stainless steel to a tolerance of +.0000, −.0005 inch. Its radial shaft play is held to .0015 inch F.I.R. or better and concentricity of shaft to pilot bushing is .0025 inch F.I.R. or better, depending on type. Shaft to mounting-plate squareness is held to .001 inch per inch.

The windings of all Fairchild potentiometers are custom-made on special Fairchild-designed machines. Guaranteed functional tolerances are ±0.5% for linear windings, ±1.0% for non-linear windings—even better in some cases.



A COMPLETE LINE EXPERTLY DESIGNED AND BUILT TO INDIVIDUAL SPECIFICATIONS

PROMPT ATTENTION TO SAMPLE ORDERS. Prompt, expert attention to special potentiometer problems is yours by merely dropping us a line. Our Potentiometer Sample Laboratory is set up explicitly to fill such needs. Where sample orders are requested, quick delivery is assured. Write today, giving complete details to *Fairchild Camera and Instrument Corporation, 88-06 Van Wyck Boulevard, Jamaica 1, N. Y. Dept. 149-20 B.*

FAIRCHILD
PRECISION POTENTIOMETERS

Ideas you can use!

These diagrams show a few of the ways in which Sylphon bellows assemblies are used—where there's a design problem involving control of temperatures or pressures. They open and close valves, dampers, etc., absorb expansion, provide packless construction, have many more uses.

We've developed bellows assemblies that are used in practically every industry. It's a specialty with us—has been for half-a-century. Skilled craftsmen and complete facilities produce *exactly* what you require, no matter how complex an assembly you need.

Your problem may parallel one we have solved for another customer. Or, we'll work with you to develop an assembly for your specific application—making important savings for you in time, trouble and money.

Wide range of metals and sizes. Write for information. Ask for idea-stirring Catalog AE-1200.

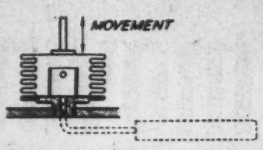


Fig. 1 Thermostatic Motor—This type of assembly is widely used in temperature regulators, etc., where a thermostatic charge is confined in the bellows and where a valve, switch, damper, etc. is to be operated in response to temperature changes.

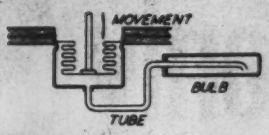


Fig. 2 Thermostatic Motor—This assembly is used where it is desirable to have the thermostatic charge confined outside the bellows and within a cup. May be used with or without remote bulb shown.

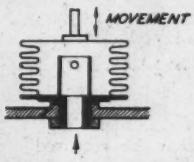


Fig. 3 Pressure Motor—Bellows assemblies are often employed to convert pressure effects into controlled movement. Fig. 3 shows such an assembly where the pressure is applied inside the bellows.

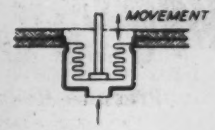


Fig. 4 Pressure Motor—This assembly differs from Fig. 3 in that the pressure is applied outside the bellows and within a cup.

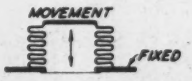


Fig. 5 Expansion Chamber—This type of assembly is employed to absorb thermal or pressure expansion. With suitable heads, it would be used to serve as a reservoir for a liquid or gas. Example: Oil reservoir for electrical cable joint.

Fig. 6 Expansion Joint—Packless and leakless construction for expansion joints used to absorb thermal expansion of pipe lines carrying steam, water, etc. May be used to absorb vibration and provide flexible connection for other applications.

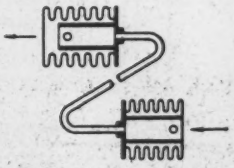


Fig. 7 Motion Transmission—Two bellows assemblies joined by a tube for hydraulic transmission of motion or power. Motive force applied may be either thermostatic or mechanical.

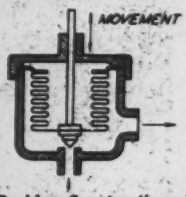


Fig. 8 Packless Construction—Illustrating packless valve construction. Same principle used to seal stem movement or adjustment in many types of apparatus.

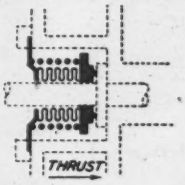


Fig. 9 Shaft Seal—Widely used for refrigeration compressors to prevent leakage around revolving shaft. Spring pressure holds nose of seal against shoulder on shaft. Another type used rotates with shaft and seals against stationary plate.

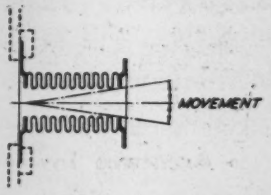


Fig. 10 Flexible Joint—Providing a means to seal a flexible joint or mechanical movement of levers, linkage, etc., against leakage where the movement must be conveyed outside an enclosure. Example: Operating stem of float switches, etc.

TEMPERATURE CONTROLS

FULTON SYLPHON
DIVISION
Knoxville 4, Tenn.

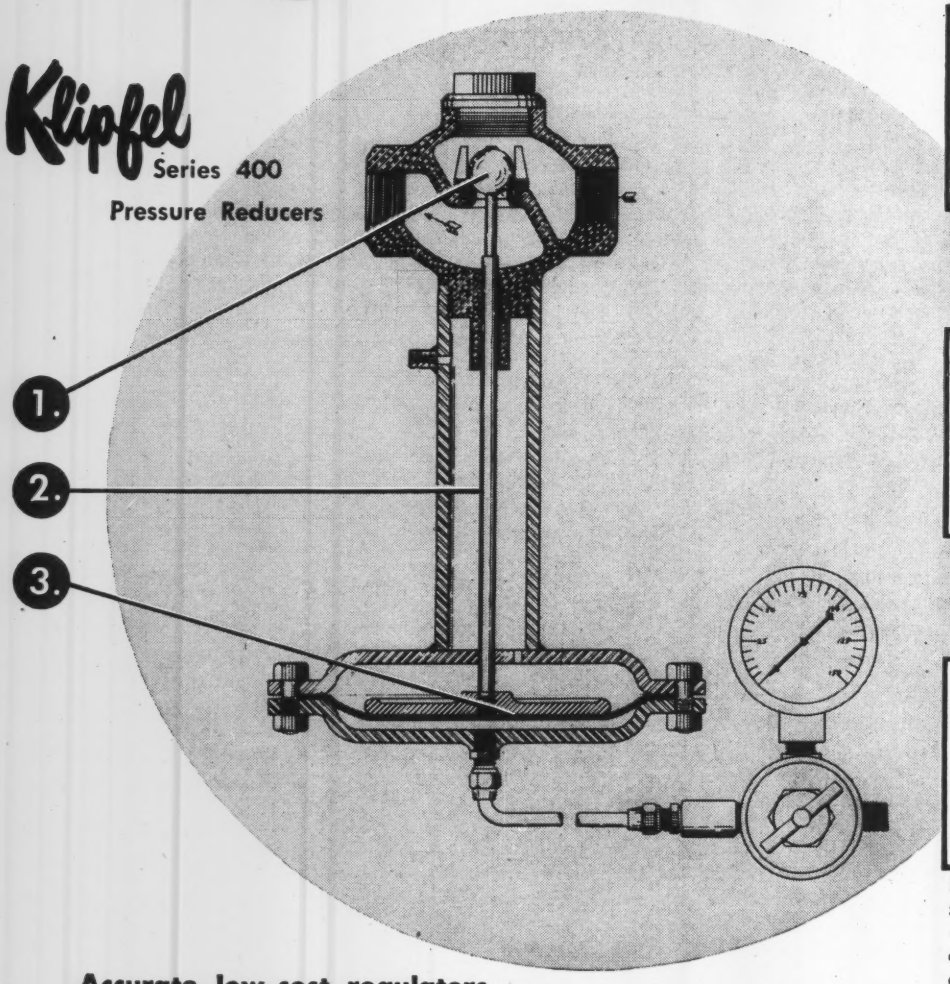
Robertshaw-Fulton CONTROLS COMPANY

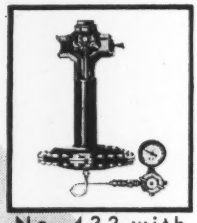
BELLOWS ASSEMBLIES • BELLOWS DEVICES

BRIDGEPORT THERMOSTAT
DIVISION
Bridgeport 1, Conn.

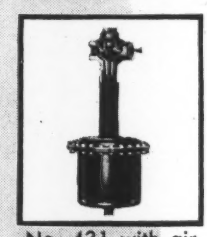
only 3 moving parts

Klipfel Series 400 Pressure Reducers

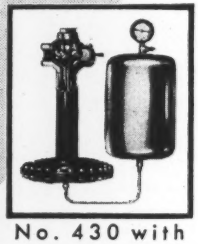




No. 432 with constant air supply—for quick, easy adjustment.



No. 431 with air dome—for isolated installations.



No. 430 with separate air tank—for variable ambient temperature.

Accurate low-cost regulators . . .

FOR longer service with negligible maintenance, operating parts are reduced to just three, inner valve, stem and diaphragm, in the Klipfel 400 Series air-loaded Pressure Reducing Valves. In addition, these 400 Series Valves provide exceptionally close regulation for an unusually low initial cost.

The stainless steel ball inner valve is a perfect sphere, extremely hard and well guided to close to a tight seat. Easily reseated if necessary . . . is self-cleansing and non-sticking. Diaphragm is always in balance . . . no stress, no bursting. Regulation is accurate and easily controlled. For increased safety, flow automatically shuts off in case of diaphragm failure.

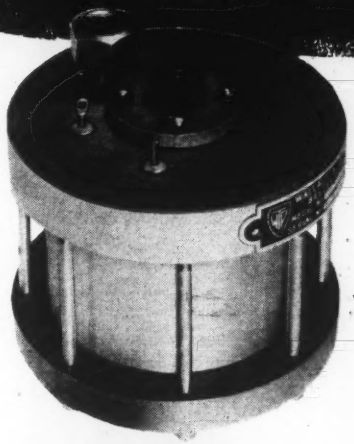
For full data on the Klipfel 400 Series Valves, for steam, air, water or gas, write Dept. DA-1 for Bulletin No. 148.

Klipfel VALVES INCORPORATED

DIVISION OF HAMILTON-THOMAS CORP., HAMILTON, OHIO

FOR DEEP VACUUM OPERATIONS

W&T PRECISION INSTRUMENTS



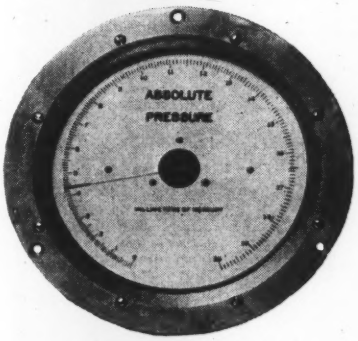
FA-193

THE W&T ABSOLUTE PRESSURE CONTACTOR

This sensitive, yet durable aneroid device is used for actuating an electric circuit at a preset value of absolute pressure.

Outstanding features of the Contactor, type FA-193, include:

Range of adjustment	0-2 mm Hg. and other ranges made to customer's specifications up to 800 mm Hg. absolute pressure.
Sensitivity	will make or break within 0.10 mm Hg.
Contact capacity	5 ma at 115 volts A.C.
Repeatability	0.10 mm Hg.
Vacuum-tight construction	
Over pressure protection	



FA-160 0-20 Scale

THE W&T ABSOLUTE PRESSURE INDICATOR

This precision instrument is used for quick, dependable indications of absolute pressures in the vacuum range. Pressure readings are independent of the nature of the gas. It is available in two dial sizes — 2¾" and 6".

Other features of the Indicator, type FA-160, include:

Range	0-20, 0-50, 0-100, 0-200, 0-410 and 390-800 mm Hg. absolute pressure.
Sensitivity	One part in 500
Accuracy	One part in 300
Over pressure protection	
Direct readings	
Rugged vacuum-tight construction	

0-100 Scale

THE W&T ABSOLUTE PRESSURE CONTROLLER

The Controller with its associated Electronic Relay furnishes precision control of absolute pressure and provides a continuous indication of absolute pressure. Independent adjustment of the "high" and "low" contacts is made through a magnetic clutch thus eliminating stuffing boxes and seals and ensuring leak-tight operations.

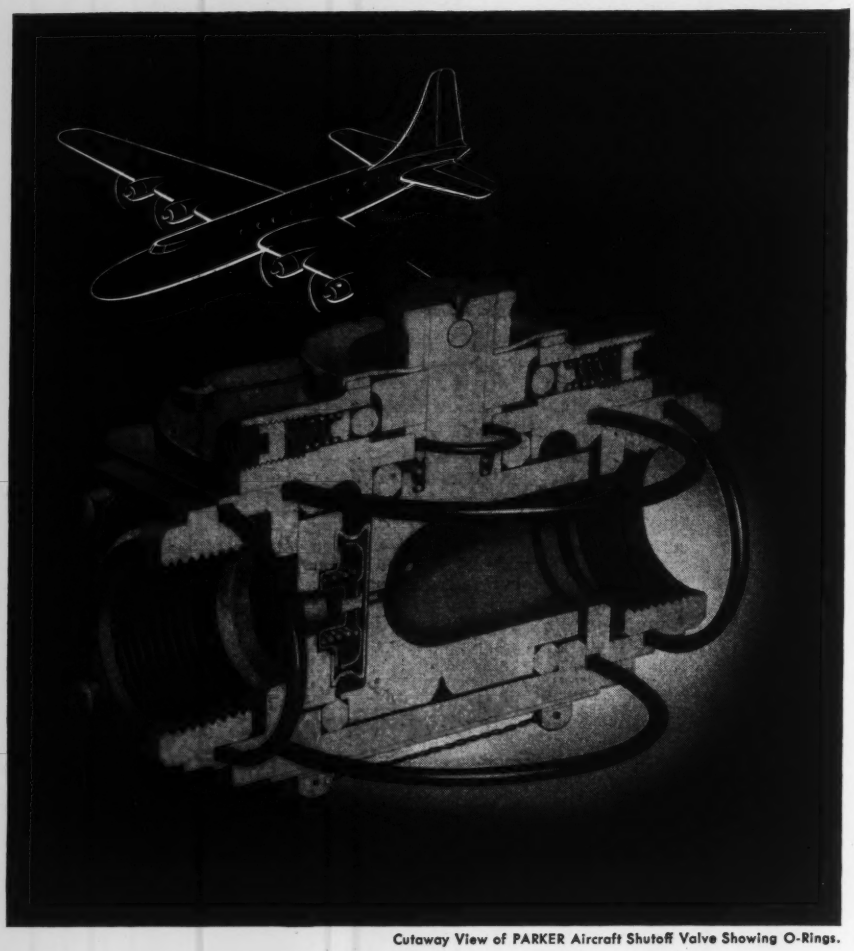
Outstanding features of the Controller include:

Range	0-20, 0-50, 0-100, 0-200, 0-410 and 390-800 mm Hg. absolute pressure.
Sensitivity	One part in 500
Accuracy	One part in 300
Relay contact capacity	5 amps, 110 Volts, 60 cycles non inductive load.
Fast accurate response	
Over pressure protection	
Vacuum-tight construction	

Additional Information Will Be Supplied On Request

WALLACE & TIERNAN
PRODUCTS, INC.
ELECTRICAL MECHANISMS AND PRECISION INSTRUMENTS
Belleville 9, New Jersey • Represented in Principal Cities

A-85

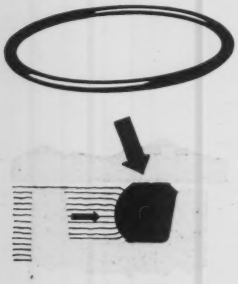


Cutaway View of PARKER Aircraft Shutoff Valve Showing O-Rings.

Leakproof Seals...Simple to use

WHEN YOU SPECIFY PARKER O-RINGS

THIS IS IT



Cross section drawing of O-ring in groove, sealing under pressure.

PARKER synthetic rubber O-rings provide perfect, leakproof sealing with economy of weight and space . . . without special complicated design . . . just a groove for the O-ring is needed. Economical in first cost, easy and simple to replace. For moving and non-moving applications.

PARKER is the one source for all standard O-rings to meet specifications covering fuel, hydraulic and engine oil services . . . and for special service O-rings of tested and approved compounds. Ask your PARKER O-ring Distributor for Catalog 5100, or write direct to The PARKER Appliance Company, 17325 Euclid Avenue, Cleveland 12, Ohio.

Parker

TUBE FITTINGS • VALVES • O-RINGS

Plants in Cleveland • Los Angeles • Eaton, Ohio • Berea, Ky.

Parker

O-RINGS

ARE STOCKED BY THESE AUTHORIZED DISTRIBUTORS

AKRON
B. W. Rogers Co.
P. O. Box 1030
Akron 9, Ohio

BOSTON
Irving B. Moore Corp.
65 High Street
Boston, Mass.

BUFFALO
Hercules Gasket & Rubber Co.
327 Washington St.
Buffalo 3, N. Y.

CHICAGO
Shields Rubber Co.
564 W. Randolph St.
Chicago 6, Ill.
Air Associates, Inc.
5300 W. 63rd St.
Chicago, Ill.

CLEVELAND
Cleveland Ball Bearing Co.
3865 Carnegie Ave.
Cleveland, Ohio
Neff-Perkins Co.
1360 West 9th St.
Cleveland 13, Ohio

DALLAS
Air Associates, Inc.
3200 Love Field Dr.
Dallas 9, Tex.

DETROIT
J. N. Fauver Co.
49 West Hancock St.
Detroit 1, Mich.

FORT WORTH
Adco Industries
1413 Electric Bldg.
Fort Worth 2, Tex.

INDIANAPOLIS
F. H. Langsenkamp Co.
229 E. South St.
Indianapolis, Ind.

LOS ANGELES
Synthetic Rubber Products Co.
1538 South Eastern Ave.
Los Angeles 22, Calif.

MIAMI
Air Associates, Inc.
International Airport
Miami, Fla.

MILWAUKEE
Allrubber Products & Supply Co.
612 South Second St.
Milwaukee 4, Wis.

MINNEAPOLIS
Van Dusen Aircraft Supplies, Inc.
2004 Lyndale Ave., South
Minneapolis 5, Minn.

NEW YORK
Durham Aircraft Service Co.
5615 Northern Blvd.
Woodside, N. Y.
Nielsen Hydraulic Equipment Co.
298 Lafayette St.
New York 12, N. Y.

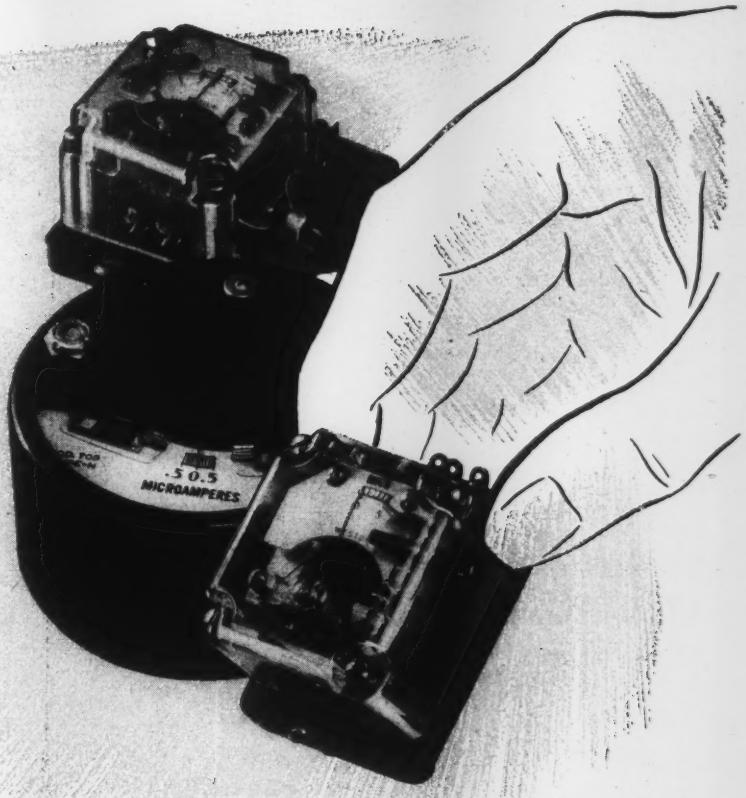
PHILADELPHIA
Goodyear Supply Co.
1506 Latimer St.
Philadelphia, Pa.

PITTSBURGH
Shields Rubber Co.
137 Water St.
Pittsburgh 22, Pa.

ST. LOUIS
Metal Goods Corp.
5239 Brown Ave.
St. Louis 15, Mo.

WICHITA
Standard Products, Inc.
650 E. Gilbert
Wichita 11, Kan.

CANADA
Railway & Power Engineering Corp., Ltd.
3745 St. James St.
Montreal 30, Que.



Boost feeble input signals with Sensitrol® ultra-sensitive relays

How many devices do *you* know of that use an amplifier to boost a feeble input signal up to where it will operate a relay? Most of them would be more reliable . . . more compact . . . more economical—if the amplifier could be omitted.

It can be omitted! For rugged Weston Sensitrol Relays operate reliably on input signals as slight as *1 millivolt* or *½ microampere,* handle substantial wattage *at 110 volts!* They require no power for excitation.

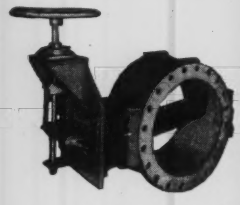
Engineering assistance is freely offered to help you adapt these Sensitrol Relays to present products, or any new problems you may have in mind. Simply consult your nearest Weston Representative, or write Weston Electrical Instrument Corporation, 606 Frelinghuysen Avenue, Newark 5, New Jersey . . . manufacturers of Weston and TAGliabue instruments.

A Type for Every Need

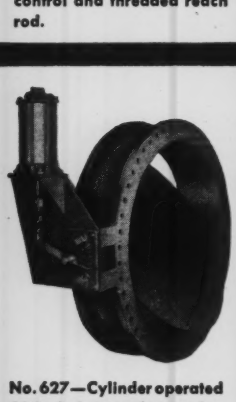
So sensitive that they operate direct on the output of a photo-electric cell or thermocouple, Sensitrol relays enable the instrument engineer to dispense with amplifiers, vacuum tubes and auxiliary power supplies. Single or double contacts, fixed or adjustable, manual or solenoid reset. Be sure you have a copy of Bulletin B-25-B, which gives detailed data on Sensitrol and other Weston relays.

WESTON *Instruments*

No. 797—24-inch heavy duty electric motor operated valve. Handwheel for manual use in case of current failure.



No. 700—20-inch class "B" cast iron valve equipped with heavy duty handwheel control and threaded reach rod.



No. 627—Cylinder operated 60-inch heavy duty valve (either pneumatic or hydraulic control).

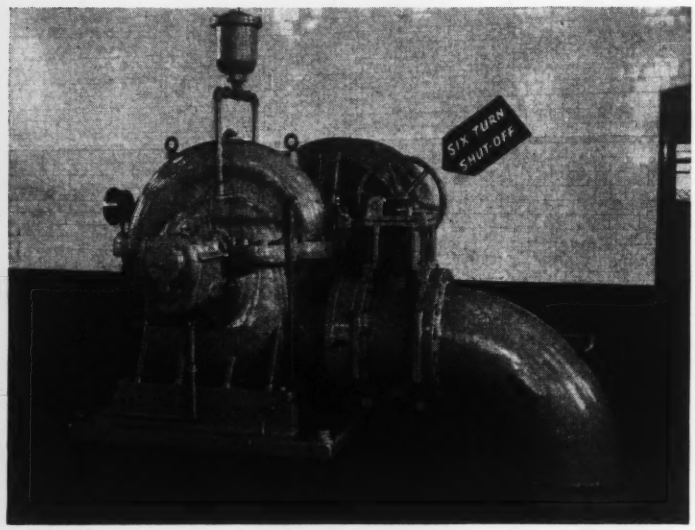
•

R-S Valves are synonymous with the simplified control and shut-off of any material that flows or is forced through a pipe, under a wide range of pressure and temperature.

•

R-S valvEvents

• EXCERPTS FROM THE R-S BOOK OF EXPERIENCE •



ATLANTIC CITY Simplifies PUMP SHUT-OFF

New pumping units of the modern Atlantic City Pumping Station supplying water for this seashore resort are equipped with 125-pound handwheel operated R-S valves.

The valve illustrated above is closed in a matter of seconds (only six handwheel revolutions required) before the pump is started in order to prevent an overload on the pump and motor. The valve is then opened gradually and easily regulated according to demand.

Such valves can be equipped with hydraulic cylinders (tapped into the pipe line before and after the pump). As long as the differential pressure remains above a predetermined value, the cylinder will hold the valve open. Power or mechanical failure will cause a drop in the differential pressure, and the cylinder will close the valve automatically. Water hammer is impossible since the valve closes only as fast as the adjustable cylinder bleeds.

Specify R-S Valves for simplified construction and operation.

R-S PRODUCTS CORPORATION
4600 Germantown Avenue, Philadelphia 44, Pa.
An S. Morgan Smith Company Subsidiary

DISTRICT OFFICES IN PRINCIPAL CITIES

INSTRUMENTS FOR LABORATORIES

Phoenix Precision Instrument Recommends G-E Galvanometer

"We prefer the G-E galvanometer because of its simplicity of zero adjustment. Furthermore, it has the short-time response period needed for use with our photometer. Because of these features, we recommend its use in conjunction with the Phoenix B-S light-scattering photometer," reports Mr. Edward J. Fuhrmeister, co-owner of Phoenix Precision Instrument Co., Philadelphia, Pa.

AIDS STUDY OF VITAL DEXTRAN

Phoenix Precision Instrument Co., manufacturer of scientific equipment, advises that its customers are currently using their light-scattering photometer and the G-E galvanometer to determine the molecular weight of Dextrans, a blood plasma substitute urgently needed by the Armed Forces and Civilian Defense Agencies. Many industrial laboratories, universities, and government agencies are using this instrument combination.

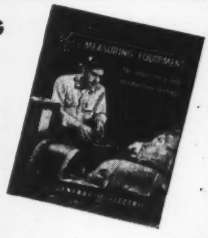
48 DIFFERENT RATINGS

Useful for measuring low values of current or voltage, General Electric portable galvanometers are supplied in forty-eight different ratings; all employ a light-beam mechanism. The galvanometers are self-contained.

1952 CATALOG

G-E Measuring Equipment

80 pages describing all of General Electric's testing and measuring devices. For free copy check GEC-1016 in coupon at right.



New Low Cost G-E PM-18 Portable Oscillograph Makes 1 Minute Oscillograms with Land Camera

The General Electric Type PM-18 Oscillograph is an entirely new, self-contained, portable recording instrument. Its advanced design provides extreme simplicity of operation and low cost unavailable in any other multi-element oscillographs.

WIDE APPLICATION

The PM-18 will measure both electrical and mechanical quantities. Electrical quantities include current and voltage phase relationships, operating speeds of relays and circuit breakers, and voltage dips caused by motor starting. The PM-18 will record rapid changes in pressure, stress, strain, acceleration, temperature, fluid flow, and sound intensity.

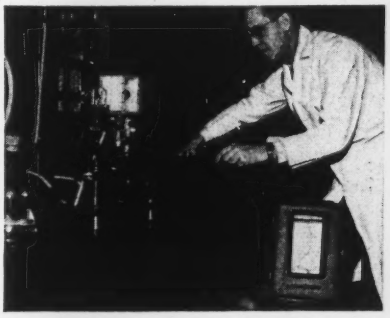
RECORDS 2, 3, OR 4 QUANTITIES

Designed for both schools and industrials, the PM-18 will record 2, 3 or 4 rapidly or slowly changing electrical or mechanical quantities simultaneously. Provided with either film pack holder, Polaroid-Land camera or continuous drive paper holder, the PM-18 will satisfactorily stop speeds up to 3000 inches per second with the Land camera, and up to 5000 inches per second with the continuous drive paper holder attachment. Use of the Polaroid-Land camera enables the operator to obtain a permanent record of the action one minute after a test is completed.

LOW COST

The PM-18 with film pack holder and 2 galvanometers is only $630.

Photoelectric Recorder Measures Electrical Potential Differences of Onion Root Tips at Bryn Mawr College



Unique use of General Electric's Type CE photoelectric recorder has been found at Bryn Mawr College in measuring the electrical potential differences in onion root tips. By recording changes in the potential of the root tip caused by externally applied currents, by changes in the contact fluid, and by changes in oxygen tension, the scientists at Bryn Mawr have been able to eliminate the tedium of manual notation. Dr. L. J. Berry, associate professor of biology at Bryn Mawr emphasized, "The photoelectric recorder's ability to record almost any quantity that can produce a d-c signal proportional to the quantity being measured has made it a basic research instrument at Bryn Mawr."

SECTION B602-223, GENERAL ELECTRIC
SCHENECTADY 5, N. Y.

Please send me the following bulletins:
Indicate:

- √ for reference only
- X for planning an immediate project
- ☐ Galvanometers GEC-694
- ☐ Photoelectric Recorder GEC-254
- ☐ PM-18 Oscillograph GEC-580
- ☐ 1952 Catalog GEC-1016

NAME .....

COMPANY .....

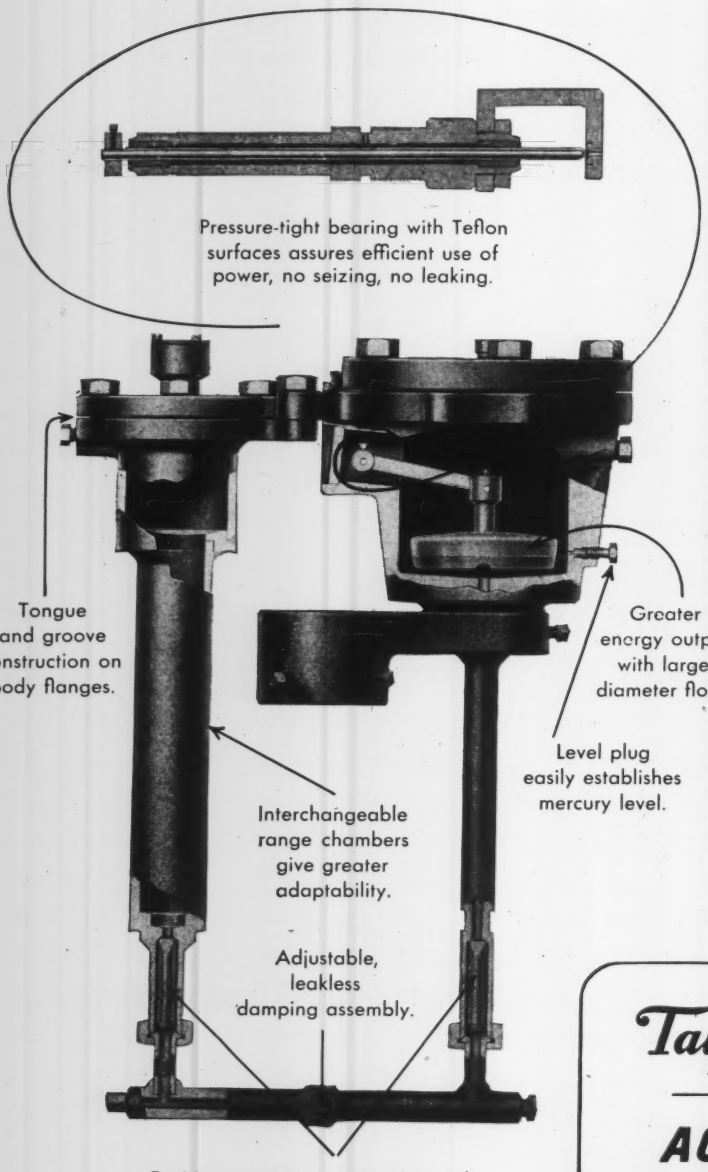
STREET .....

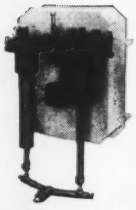
CITY ..... ZONE ..... STATE .....

GENERAL ELECTRIC

Taylor Mercury Manometer

DOESN'T SEIZE, DOESN'T LEAK!


Pressure-tight bearing with Teflon surfaces assures efficient use of power, no seizing, no leaking.
Tongue and groove construction on body flanges.
Greater energy output with large diameter float.
Level plug easily establishes mercury level.
Interchangeable range chambers give greater adaptability.
Adjustable, leakless damping assembly.
Positive overrange protection with mercury-submerged Nylon check valves.



HERE's a mercury manometer that's ideal wherever you need something *better* than conventional flow, liquid level and other differential pressure measuring instruments. Check these features:

Greater accuracy results from greater power of extra-large float efficiency transmitted by mirror-finished shaft and Teflon bearing; also straight line calibration.

Greater adaptability, thanks to six interchangeable range tubes (*10", 20", 50", 100", 200" and 400" of water*) which, except 10", may be over or under ranged 33⅓%.

Maintenance is easy, because the low pressure chamber cover permits easy access to float and lever arm during calibration, and the entire pressure tight bearing can be easily, economically replaced.

Performance is dependable, because the submerged check valves give positive shutoff, damping valve is adjustable under full pressure, and there's ample room in the mercury chambers to accommodate surges.

This is just one of many Taylor Instruments to measure, record and control practically any process variable with new high accuracy and dependability. *Write for Catalog 98175* or ask your Taylor Field Engineer how Taylor can help you cut cost, protect your product quality. Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

Guest Editorial

A Consumer Talks Back to the Instrument Manufacturer

By J. R. CHURCHILL*, Chief, Analytical Division
Aluminum Research Laboratories, Aluminum Company of America

IN ADDITION to demanding extreme quality, low price, and prompt delivery, the buyers and users of scientific apparatus expect and need efficient service of two types from the manufacturer. First, they need service in installation, adjustment, calibration, repair, and maintenance. This type of service varies with the equipment and becomes increasingly important as the complexity and delicacy of the equipment increases.

The other type of service required is along the lines of technical information and consultation, and it is this phase of service that suppliers frequently neglect or handle ineptly. An outstanding job of information dissemination is the typical catalog of the two or three largest scientific supply houses. These books serve both as Primers for the tyros and as reference texts for experienced workers in the field. Unfortunately, the smaller and more specialized manufacturers and suppliers often are unable to supply adequate literature on their own products.

Consulting service is important in all fields of apparatus manufacture. Users or prospective users should have easy access to people in the manufacturer's organization who can and will talk expertly about design, application, and performance of the apparatus offered. Too often both customer and producer suffer from having these contacts handled by pleasant young people of sketchy or nonexistent technical backgrounds.

The research and development programs of apparatus companies should be directed towards increased quality, convenience, and serviceability of equipment. On laboratory instruments, versatility and simplicity are equally important but often conflicting needs. Modern trends are more and more towards elaborate, highly-automatic devices. Automatic features are obviously desirable when there is a definite increase in objectivity of measurement, precision of control, or savings in labor. Too often, however, it is assumed that to be automatic is a virtue in itself, and there seems to be a trend towards the creation of robots which replace fewer men than are required to maintain and adjust them.

As a purchaser and user of scientific equipment, the author feels that price should be de-emphasized in the design and manufacture of scientific equipment. Industry is willing to pay for quality in terms of function and serviceability. In selecting scientific apparatus, it is often good economy to pay twice as much for a slightly superior piece of equipment. The popular practice of shaving pennies from the cost of elaborate and necessarily expensive equipment by using inferior minor components is a frequent complaint of the user. Especially deplorable is the use of cheap radio parts in the control and measuring components of otherwise high-quality apparatus.

The technical departments of the larger instrument manufacturers are concerned with the adaptation of apparatus invented elsewhere, the improvement of existing equipment, and the control of quality. Development of radically new and different items of apparatus is left largely to the smaller and more specialized companies. This has worked out relatively well from the consumer's standpoint.

The consumer has learned to rely on the larger manufacturers for steady supply and reliable routine service on standard items, and for information and consultation of a broad and general nature. When he needs something new or specialized, or has a specific problem requiring consultation in a highly specialized field, the small company generally serves him better.

The proving ground of scientific apparatus is in the laboratory of the user. Here alone will be found the practical answers to the questions of utility and serviceability. Here, too, is the best source of information as to the present and future needs of the users of equipment and of ideas and suggestions for new or improved products. Figuratively at least, the development laboratory of the successful apparatus manufacturer is spread among the laboratories of his customers, and only a minor fraction is located on his own property. All of this adds up to the most pressing need in the field of scientific apparatus—better liaison among the scientific people of the manufacturers, suppliers, and users of such equipment.

Users of scientific equipment are conscious of and grateful for the contributions of manufacturers of scientific equipment to our modern technology. Whether we call this the Scientific Age, the Atomic Age, or the Age of Technology, the important and key position of the makers of the tools and gadgets of science is self-evident.

*Summary of a talk presented November 29 in the Hotel New Yorker, New York City, before the Laboratory Apparatus and Optical Sections of the Scientific Apparatus Makers Association.

Help Your Associates

YOUR attention is directed to several changes beginning in this issue. We hope you like the new cover, the new headings, the new arrangement. The New Instruments Department now immediately follows the Editorial Page. This puts the "news" up front—and also puts the feature articles closer to the excellent feature articles in the Journals. Note the expanded pictorial coverage in every department of the magazine.

Our thousands of readers know how important *Instruments* is to them. Our articles and news releases on new instruments and new literature are the basis by which all instrument men can keep abreast of the field of measurement and control in every important respect.

But we are constantly surprised still to find instrument men—men who use instruments of any type for measurement, inspection, testing, and control—who are not regular readers of *Instruments*. Some of these men may have recently entered instrument work and therefore are not familiar with *Instruments*. Each of you can help your associates by pointing out how much can be learned from a year's subscription to *Instruments*—indeed how vital this information is to any man who uses instruments in research, development, and production.

In each issue is included a home-study course in electronics that can be of greater value than the cost of a subscription—by a factor of many times. Each new subscriber receives the first *Handbook of Measurement and Control* and the *Instruments Index*, both of which have a value far exceeding the cost of a subscription. Tell your associates of the wealth of material that accompanies a subscription to *Instruments*. You will render a service not only to your associates but also to your organization if you will pass along the subscription cards, bound into this issue, to those who should be interested. —MHA

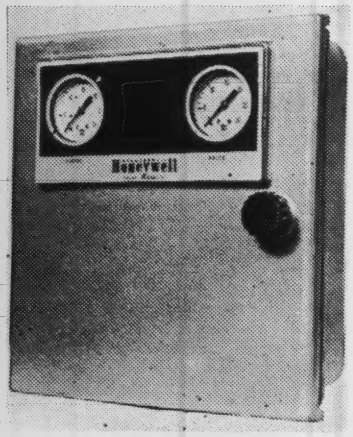
The Month's NEW INSTRUMENTS

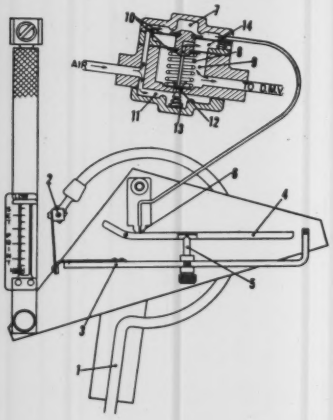
In this department we report each month new devices for measurement, inspection, testing, computing, metering and automatic control—in the form of concise technical descriptions.

FOR FURTHER INFORMATION USE THE POSTAGE-FREE ORDER CARD ON PAGE 113

Pressure Controller

New "Pressure Pilot" is compact non-indicating pressure controller for regulating control valves. Employs bourdon tube to measure pressure and flapper-





and-nozzle arrangement to produce an air signal directly to valve. Features include accurate set-point adjustment. Control action can be changed from direct to reverse in seconds.—*Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Penna.*

Mention No. 101 when filling out card.

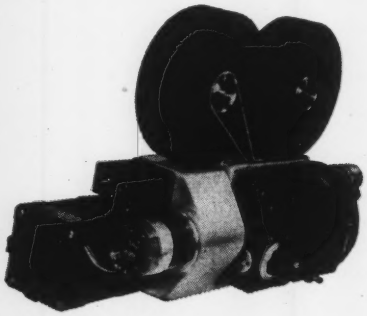
Photoelectric-system Controller

New "CE2C Controller" protects photoelectric systems from giving false alarms when system voltage drops because of lightning or other causes. Re-establishes system operation when voltage returns to normal. Improves performance of all photoelectric protective devices.—*Sola Electric Co., 4633 W. 16 St., Chicago 50, Ill.*

Mention No. 102 when filling out card.

Synchronized Camera System

New "Servo-Sync" camera-drive system synchronizes a series of motion-picture cameras, taking their pictures

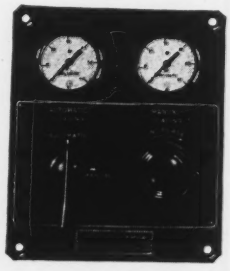


at the same time to close tolerance. Maximum shutter deviation of circular-rotating camera shutters is less than 1 deg. Any number of cameras can be synchronized.—*Photographic Div., J. A. Maurer, Inc., 37-01 31st St., Long Island City 1, N. Y.*

Mention No. 103 when filling out card.

Oil-pressure Loader

New panel-mounted remote oil-pressure loader manually controls oil pressure to devices normally operated auto-

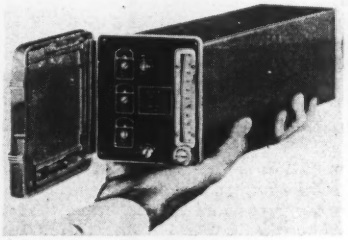


matically. Both automatically controlled and manually controlled pressures are indicated on gages; operator can avoid discontinuity by matching pressures before switching modes of control. Standard output is 0-60 psig. with oil supply pressure of 100 psig.—*Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.*

Mention No. 104 when filling out card.

Electronic Control Unit

New "Autronic" miniature all-electronic process-control unit incorporates functions of proportion, reset, and rate-time (derivative)—with propor-

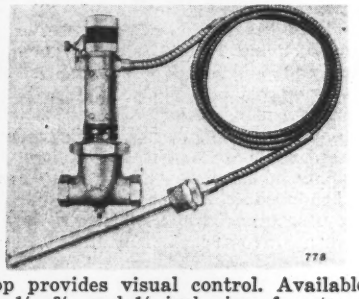


tional band always in operation. All adjustments are readily made with screwdriver. Dials are calibrated on face. Doors have magnetic closure. Proportional band is from 2 to 200 percent (wider ranges available). Reset from 0.03 to 20 repeats per min. Rate-time is graduated from 0.05 to 8 minutes with "off" position. Available with or without built-in set-point scale. Input is a 0.0 to 0.5 volt a-c. signal from primary element. Controller amplifies and modulates input voltage for desired mode of control. Requires only 4.625 x 5 inches panel space. Plug-in feature makes it interchangeable without disconnecting any wiring.—*The Swartwout Co., 18511 Euclid Ave., Cleveland 12, Ohio.*

Mention No. 105 when filling out card.

Temperature Regulators

New "Type UBA" self-operated temperature regulator is packless, single-seated, fully balanced, and hermetically sealed for reliable operation under adverse conditions. Dial adjustment on



top provides visual control. Available in ¼, ⅜, and ½ inch sizes for steam pressures to 150 psig., and control of temperature between 30 and 325 deg. F. Control can be applied over a 60-deg. F. range. Supplied with eight feet capillary tubing and 1-inch NPT connection.—*Farris Stacon Corp., 610 Commercial Ave., Palisades Park, N. J.*

Mention No. 106 when filling out card.

Industrial Resistance Thermometers

New line of resistance thermometers are for temperatures ranging from minus 100 F. to plus 300 F. Available in three basic types: "HP-11" is resistance-thermometer indicator; "HP-

13" is two-position controller or protector; "HP-14" is three-position controller. Each has either flush or surface mounting. All thermometers use crossed-coil moving element and 3.25-pound alnico V magnet. Entire mechanism is in dust-tight, moisture-resistant assembly. —*Meter and Instrument Dept., General Electric Co., Schenectady 5, N. Y.*

Mention No. 107 when filling out card.

pH Meter

New "Model N" pH meter is light, compact, and rugged. Weighs less than 8 lbs., complete. Electrode support can be rotated to permit instrument to be

used in either horizontal or vertical position. Electrodes plug in side of case, permitting quick interchangeability. Covers pH range from 0 to 14; can be used at temperatures from freezing to boiling. Is accurate to 0.05 pH and has built-in temperature compensation.— *Beckman Instruments, Inc., South Pasadena 47, Calif.*

Mention No. 108 when filling out card.

pH Indicator and VTVM

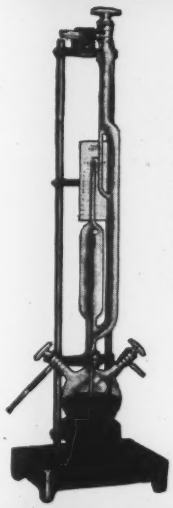
New line-operated pH indicator and vacuum-tube voltmeter is unaffected by normal fluctutations in line voltage or by zero drift of amplifier. Circuit employs d.c. to a.c. conversion, a.c. amplification, and conversion back to d.c. for voltage feedback. Conversion stabilizes zero; feedback stabilizes gain. Makes glass electrode measurements to within 0.02 pH on grounded or ungrounded solutions. Continuous pH 0 to 14 scale eliminates range-changing. Tempera-

WELCH

VACUUM GAUGES

2 Types

McLeod Vacuum Gauge



—Features—

Tubes can be readily cleaned by direct mechanical operation where necessary, due to the unique construction of large openings directly in line with the capillary tubes.

Scale range 30 microns—Smallest calibration .005 micron.

Direct reading logarithmic scale.

Scales ruled on heavy white celluloid.

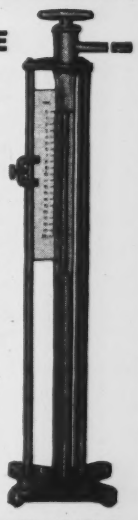
Mounted on an all-metal heavy base.
Complete as shown, but without mercury—

EACH $170.00

No. 1453

Dubrovin Vacuum Gauge

DIRECT READING - ECONOMICAL - SIMPLE TO USE-UNIQUE MAGNIFIED SCALE



Absolute direct reading and instantly responsive to pressure variations. This gauge is particularly suitable where economy or simplicity of equipment eliminates the possibility of using differential gauges such as the McLeod type. It is superior to the U type manometer because of the magnification of the scale. One type is offered with a 6 to 1 magnification and another with a 9 to 1 magnification. This means that if you are attempting to measure the vacuum indicated by 1 mm. of difference in level on the ordinary closed U type manometer, this new gauge will point out a difference 6 mm. long (or 9 mm. long). Type A is 40 cm. high and Type B is 57 cm. high.

1451 C. DUBROVIN GAUGE TYPE A table model, 20 mm. range, 6 to 1 scale, without mercury Each, $42.00
1451 E. DUBROVIN GAUGE TYPE B table model, 20 mm. range, 9 to 1 scale, without mercury Each, $50.00
1451 G. DUBROVIN GAUGE TYPE A wall model, 20 mm. range, 6 to 1 scale, without mercury Each, $42.00
1451 J. DUBROVIN GAUGE TYPE B wall model, 20 mm. range, 9 to 1 scale, without mercury Each, $50.00

Also made from Pyrex brand tubing at the same prices. No. 1451C

W. M. WELCH SCIENTIFIC COMPANY

1515 SEDGWICK STREET, DEPT B CHICAGO 10, ILLINOIS, U. S. A

Century

RECORDING GALVANOMETERS

The Century Model 210 Galvanometer has been designed and tested for the utmost in performance under any conditions. The unique small tubular type construction permits their installation in practically any type or make of photographic recording oscillographs. These galvanometers are offered at low cost over a wide range of frequencies and sensitivities to satisfy most recording requirements. For additional information, write for our Catalog No. CGC 206.

Manufactured under Century Pat. 2439576, also licensed by Kannestine Laboratories Patent 2149442.

Century

CENTURY GEOPHYSICAL CORPORATION

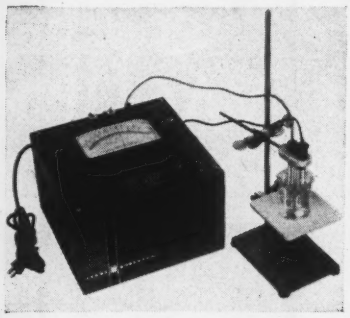
1340 North Utica

Tulsa, Oklahoma

EXPORT OFFICE: 149 Broadway, N. Y. — 1505 Race Street Philadelphia

World's Largest Manufacturer of Geophysical and Special Galvanometers

NEW INSTRUMENTS

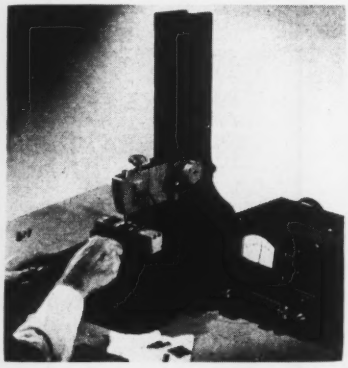


ture compensator is graduated from 0 to 100 C. Automatic temperature compensation can be provided. As VTVM, external circuits can have up to 2000 megohms resistance. Current drain does not exceed 1×10^{-12} ampere at null balance. Four voltage scales of 0 to 700, -700, 1400, and -1400 millivolts are available for redox, potential, and polarized current measurements.—*Leeds & Northrup Co.*, 4934 *Stenton Ave., Philadelphia* 44, *Penna.*

Mention No. 109 when filling out card.

Microcomparator

New "Micro-Ac" electronic microcomparator reads in millionths of an inch and is designed for gage use. Consists of (1) induction-type gage head adjustably mounted on rigid stand, and (2) high-stability 4-tube amplifier



with 2-scale meter. Amplifier is free of drift. Meter reads 0.000001 and 0.000010 in. per div. Accommodates work of any height to 12½ in. above top of standard anvils. Features include 4-ounce contact pressure and replaceable contact tip with overtravel protection.—*Graham-Mintel Instrument Co.*, 735 *Carnegie Ave., Cleveland* 15, *Ohio.*

Mention No. 110 when filling out card.

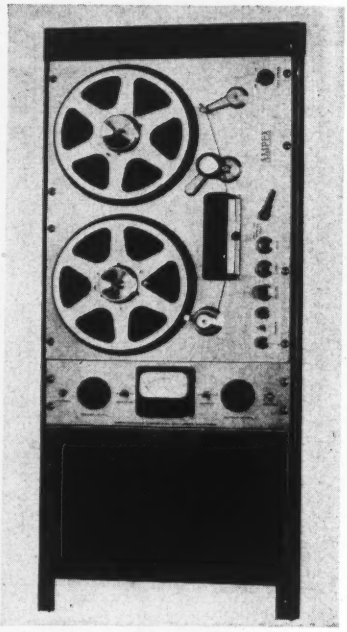
Farm Scale

New farm scale is designed for farm-weighing operations. Indicates true weight of any object up to 2500 pounds. Has large 15-in. dial and can be carried.—*Dillon & Co., Inc.*, 5410 *W. Harrison St., Chicago* 44, *Ill.*

Mention No. 111 when filling out card.

Tape Recorder

New "Model 307" magnetic tape recorder, designed for telemetering instrumentation, has frequency range of

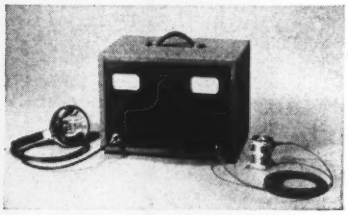


from 100 to 100,000 cps. Tape speeds are 60, 30, and 15 in. per sec.—*Ampex Electric Corp., Redwood City, Calif.*

Mention No. 112 when filling out card.

Vibration Analyzer

New "Vibration Discriminator" measures frequency and amplitude of vibration. Signal from vibration pickup is



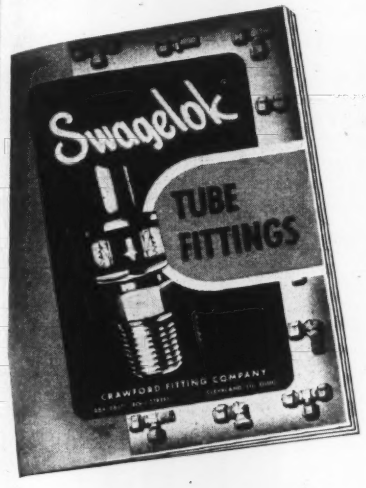
analyzed electronically to give frequency and amplitude. Stroboscopic lamp, synchronized with vibration, locates offending part. Calibrated tachometer circuit can operate stroboscopic lamp independently.—*Lion Mfg., Inc., P.O. Box* 1348, *Columbus* 16, *Ohio.*

Mention No. 113 when filling out card.

Flame Failure Safeguard

New "System FP-4 Fireye" photoelectric flame failure safeguard instantly cuts off fuel and sounds alarm when flame fails. Consists of electronic control "Type 26SJ5" and "Firetron Scanner Type 48PT1." Scanner contains photoconductive cell that gives instantaneous response to flame failure. Control is housed in sturdy dust-tight steel case, and contains power supply and relay system. Fail-safe circuits assure instant shut-down on failure of any com-

IT'S FREE
IT'S NEW!



Swagelok*

TUBE FITTINGS CATALOG

Every instrument man, process piping man, designer, engineer, and purchasing agent should have this new Swagelok Tube Fittings Catalog. It gives you at a glance, detailed, illustrated data on the complete line of Swagelok tube fittings in brass, aluminum, steel, stainless steel, and Monel. It's your complete guide to economical, torque-free, leakproof joints in all instrumentation and process piping lines.

FREE— Send for Swagelok Catalog B-151 today. Address Dept. 1

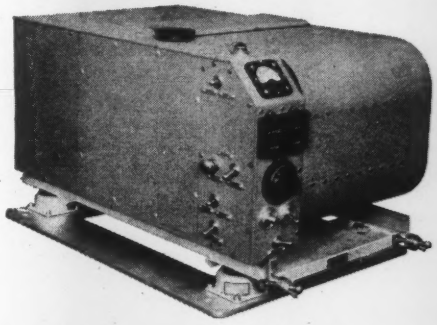
* Patented

CRAWFORD FITTING CO.
884 E. 140th Street, Cleveland 10, Ohio

SWAGELOK FITTINGS AVAILABLE IN: BRASS, ALUMINUM, STEEL, STAINLESS STEEL, MONEL

COME TO YOU COMPLETELY ASSEMBLED, FINGER TIGHT

Century INDUSTRIAL
RECORDING OSCILLOGRAPH
FOR VIBRATION, TEMPERATURE, STRESS, STRAIN ANALYSIS



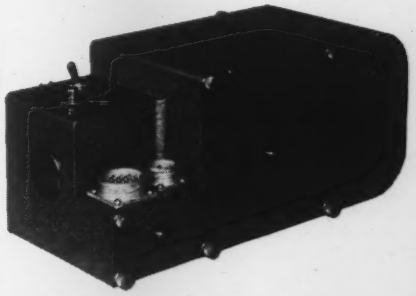
MODEL 408 OSCILLOGRAPH

The Century Model 408 recording oscillograph was designed expressly for airborne and mobile operation. As with all Century products, this oscillograph incorporates the utmost in design and workmanship, along with improved features, yet it remains simple in its operation and maintenance.

FEATURES:

- Size: 20" long, 12½" wide, 8⅞" high.
- Weight: 60 pounds.
- Number of Recording Channels: 6 to 50.
- Detachable daylight loading magazine accommodating a roll of paper or film 8" x 200'.
- Friction roller type paper drive by governor controlled electric motor with separate motor for takeup drive.
- Paper speeds continuously and instantly variable without changing gears or sprockets.
- Separate optical system for viewing before or during recording.
- Glow tube timing system photographing .01 second and .1 second lines. .01 second lines instantly removable by toggle switch for slower speeds.
- Data numbering at beginning of record.
- Footage indicator showing amount of paper remaining in magazine.
- Automatic record length control.
- Trace identification.
- Remote control unit.

MODEL 409 OSCILLOGRAPH



The Century Model 409 oscillograph has been designed for recording data where space and weight requirements are limited. This oscillograph has been tested to record faithfully while subjected to accelerations up to 20 G's.

FEATURES:

- Size: 5" x 5" x 11".
- Weight: 11 pounds.
- Cast Aluminum case.
- Paper speeds variable ½" to 12" per second.
- Detachable daylight loading magazine with a capacity of 3⅜" x 50' paper or film.
- 2 to 12 individual channels.
- Trace identification.
- Trace viewing.

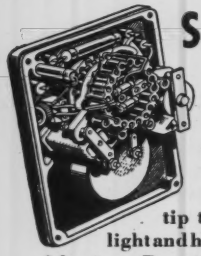
For Complete Information Write 1340 North Utica

Century GEOPHYSICAL CORPORATION
TULSA, OKLAHOMA

1505 Race Street
Philadelphia, Pa.

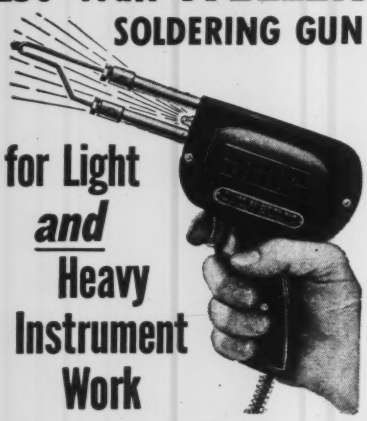
EXPORT OFFICE:
149 Broadway, New York

Adjust Heat INSTANTLY for ALL TYPES of Soldering



Controlled dual heat—on in 5 seconds, off when you release trigger—lets you adjust tip temperature for light and heavy instrument soldering. Precision balance, longer reach and tip construction ideal for delicate jobs. Rating up to 250 watts speeds heavy work. Time-and-power savings pay for your Weller Gun in a few months.

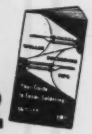
250-Watt WELLER SOLDERING GUN for Light *and* Heavy Instrument Work



- **TRIGGER-SWITCH CONTROL**—Ideal for intermittent work. No need to unplug gun between jobs.
- **5-SECOND HEATING**—No waiting, no wasted current.
- **PRECISION BALANCE**—Simplifies delicate work.
- **SOLDERLITE**—Spotlights the work.
- **LONGER REACH**—Slides easily into tight spots.
- **WELLERTIP**—Chisel shaped for faster heat transfer. Over/under terminals brace tip for heavy duty.
- **DUAL HEAT**—Single heat 200 watts; dual heat 200/250 watts; 120 volts, 60 cycles. For all instrument soldering.

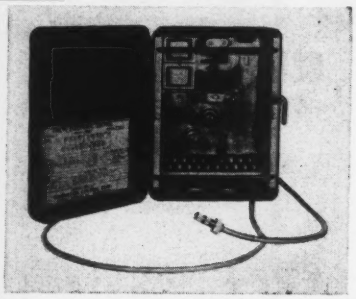
See the 250-watt Weller Soldering Gun at your distributor, or write for bulletin direct.

SOLDERING GUIDE—Get your new copy of "Soldering Tips"—revised, up-to-date, fully illustrated 20-page booklet of practical soldering suggestions. Price 10c at your distributor, or order direct.



WELLER ELECTRIC CORP.
800 Packer Street, Easton, Pa.

NEW INSTRUMENTS

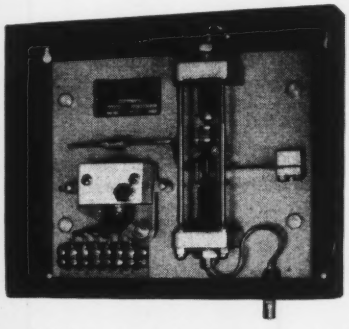


ponent. Supply voltage is 115/208/230 volts, 50/60 cycles; load rating is: Burner Motor—¾ hp., 115/230 v., 60 cycles.—*Combustion Control Corp.*, 77 *Broadway, Cambridge* 42, *Mass.*

Mention No. 114 when filling out card.

Absolute Pressure Transmitter

New "Atcotran" electromechanical transmitter consists of two opposing bellows connected to cantilever-beam spring and differential transformer.



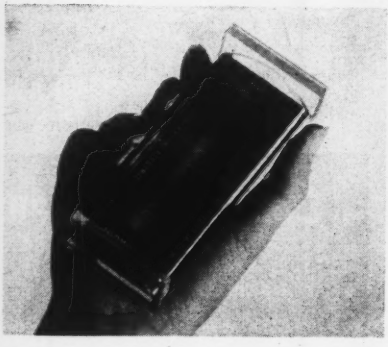
One bellows connects to system to be measured; other bellows is absolute-pressure reference. Variation in atmospheric pressure is compensated for by evacuated and sealed reference bellows. Available in 5 ranges between 0-50 mm. mercury to 0-30 in. mercury. —*Automatic Temperature Control Co., Inc.*, 5200 *Pulaski Ave., Philadelphia* 44, *Penna.*

Mention No. 115 when filling out card.

Thin-film Step Gage

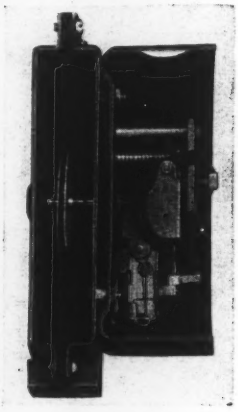
New "Step Gage" accurately measures thickness of thin films by means of color comparisons. Consists of glass plate with film of barium stearate in series of steps. Each step is one microinch thicker than preceding one. When illuminated by white light, each step reflects a color determined by its thickness. Thickness of unknown film is found by comparison with colors on gage. Range is from 2 to 16 microinches. —*Special Products Div., General Electric Co., Schenectady* 5, *N. Y.*

Mention No. 116 when filling out card.



Differential-pressure Controller

New "Mercoid Diaphragm Differential Pressure Controls" automatically open or close electrical circuits according to change in difference between two pressures or vacuums, air or gas. Two



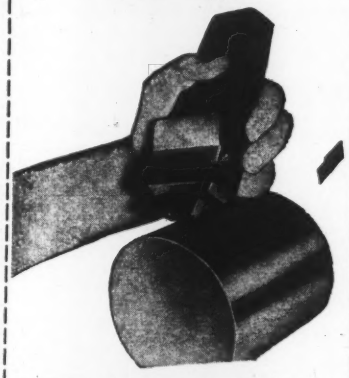
pressure chambers are separated by flexible diaphragm which actuates either one or two hermetically-sealed mercury switches. Various types are available in ranges 6.0-in. vac. to 6.0-in. press. and 30.0-in. vac. to 30.0-in. press. Each switch has load capacity of 20 w., 115 or 230 v., a.c. or d.c.; 0.9 amp. at 24 v. or less. Motor rating, 1/60 hp.—*The Mercoid Corp.*, 4201 *Belmont Ave., Chicago* 41, *Ill.*

Mention No. 117 when filling out card.

Chronometric Tachometer

New "Jaquet Speed Indicator" is chronometric-type tachometer with ball-bearing spindle and extra scale divi-

Number ROUNDS
with STRAIGHT Line Steel Type



Hercules Holders are made in several sizes to take standard Hercules "Shoulder-style" Heavy Duty Steel Stamping Type.

On rounds, a wedge-shaped spacer gives a concaved stamping face. On concavities, an extended wedge spacer gives a convexed stamping face. On flat surfaces, the type is used in a regular straight line holder.

Write for details and price list.

The ACROMARK *Company*

3-11 Morrell St. ELIZABETH 4, N. J.

MICO
"SOLDERUX"
INSTRUMENT
SOLDERING FLUXES
Non-Corrosive

Especially recommended for soft soldering fine wires and small parts of many metals including steel, brass, chromel, constantan, nickel, silver and copper.

MICO SOLDERUX LIQUID
for vigorous action

MICO SOLDERUX CREAM
for strong action

MICO SOLDERUX PASTE
for milder action

These fluxes are unique in that chemical action, so necessary in cleaning metals of oxides, grease, and dirt, does not begin until soldering temperatures are reached. When work cools, any remaining flux subsides into a chemically inert material of low conductivity having non-hygroscopic properties.

1 OZ. TRIAL JAR—50c

MICO INSTRUMENT CO.
86A TROWBRIDGE STREET
CAMBRIDGE 38, MASS.

Check THESE 7 ADVANTAGES
OF SANBORN DIRECT WRITING RECORDING SYSTEMS

1 COMPLETE SYSTEM or SEPARATE COMPONENTS
Sanborn equipment is available as complete 1-, 2-, or 4-channel systems *ready for use*, or as separate instruments (Amplifiers, Preamplifiers, and Recorders), to be combined or integrated by the user with other equipment.

2 NO INK
Permanent records are produced with heated stylus on heat responsive, continuous plastic coated chart paper. Elimination of ink permits, among many advantages, use of the recorder in any position, at any angle, and at high altitudes.

3 RECTILINEAR RECORDS
Records are in true rectangular coordinates (with *negligible* tangent error), permitting more accurate correlation when two or more channels are used simultaneously.

4 HIGH TORQUE MOVEMENT
The writing arm is driven by a D'Arsonval moving coil galvanometer with an extremely high torque movement (200,000 dyne cms per cm deflection). Sensitivity 10 m.a./cm deflection.

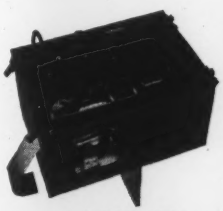
5 WIDE CHOICE OF PAPER SPEEDS AND RECORDING CHANNELS
Basic choice of 1-, 2-, or 4-channel models. Single channel standard speed 25 mm/sec., slower speeds available. Two channels, 10 speeds — 5 and 0.5, 10 and 1, 25 and 2.5, 50 and 5, 100 and 10 mm/sec. Four channel, eight speeds — 50, 25, 10, 5, 2.5, 1.0, 0.5, and 0.25 mm/sec.

6 CODE & TIME MARKINGS
All models provide a means of inserting timing pips in the record once each second independently of the paper drive, and code markings at will.

7 INTERCHANGEABILITY
Ready interchangeability of Amplifiers and Preamplifiers in all Sanborn systems permits a wide variety of recording combinations.

WRITE FOR COMPLETE CATALOG

If your problem involves recording any phenomena (individually, or simultaneous recording of up to four) that can be expressed electrically, you will find Sanborn equipment ideally suited to your requirements.



1-CHANNEL

2-CHANNEL

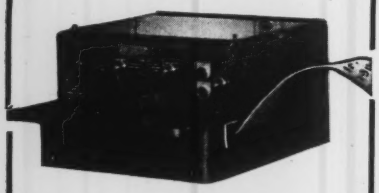
4-CHANNEL

INDUSTRIAL DIVISION **SANBORN CO.** CAMBRIDGE 39, MASS.

The Ametron Electronic Scale records the accurate weight applied to the load cells by printing on ticket, tape, or ledger sheet.

The unit makes weighing easier, quicker and more exact. Being compact, installation is simple as compared with complicated lever systems. It eliminates problems encountered in maintenance because of accessibility of load cells and interchangeability of cells and recorder components.

The Recorder is a full figure step cam controlled mechanism. It includes provision for multiple ranges to give increased capacity with high sensitivity and accuracy.



Write for our booklet "The Way to Weigh"

STREETER-AMET CO.

4101 Ravenswood Avenue

Chicago 13, Illinois

Branches in Pittsburgh, Pa. and Birmingham, Ala.

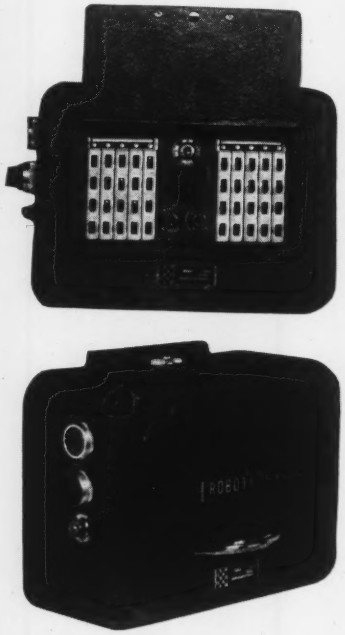
NEW INSTRUMENTS

sions. Guaranteed accuracy is 0.5 percent. Four models cover low speeds (0.02 rpm./div.) to high speeds (100,000 rpm.) Indicators measure revolutions in periods of 3 and 6 sec., and are pocket size.—*Herman H. Sticht Co., Inc., 27 Park Pl., New York, N. Y.*

Mention No. 118 when filling out card.

Cycle Controller

New "Type E 304 Robatron" automatic cycle controller is particularly suited to industries where press "bumping" or "breathing" is essential. Push-

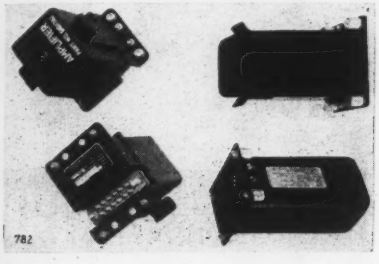


button keyboards set up cycles in a few seconds. Includes operating pushbuttons facing press operator, lockable keyboard cover at side, solenoid valve, and internal pressure switch.—*Emmett Mach. & Mfg. Inc., 2249 14th St., Akron 14, Ohio.*

Mention No. 119 when filling out card.

Servo Amplifiers

Two new 400-cycle servo amplifiers feature hermetically-sealed, oil-filled packaging for greater heat dissipation, longer tube life, greater resistance to vibration and shock, and saving in space. Outputs are 9 watts at 115 volts and 3 watts at 30 volts. Type "SA104H" is for use in high-performance servo loops and incorporates a derivative control network. Type "SA112H" is for use in analog-computer servo loops and is designed for velocity damping, furnished by tachometer generator.—*Servomechanisms, Inc., Post and Stewart Ave., Westbury, Long Island, N. Y.*



Mention No. 120 when filling out card.

Electric Stop Watch

New "Lab-Chron" electric stop watch is said to be only unit of its kind where

synchronous motor and timer count 1/10 sec. to 9999.9 sec.; or in minute model, 1/100 min. to 999.99 min.—*Laboratory Industries, Inc., 4710 W. North Ave., Chicago 39, Ill.*

Mention No. 121 when filling out card.

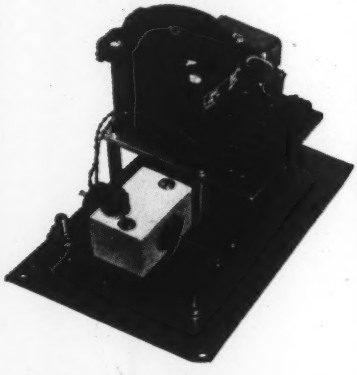
Liquid Filter

New synclinal type filters for sump or line installation on all hydraulic and low-pressure liquid recirculating systems are available from 5 to 100 gpm. Choice of filter mesh from 30 to 200. 75-gpm. filter is only 12.5-in. long with 6.5-in. dia.—*Marvel Engineering Co., 625 W. Jackson Blvd., Chicago, Ill.*

Mention No. 122 when filling out card.

Electronic Servomechanism

New "Atcotran" electronic servomechanism remotely positions pointers, counters, cams, wheels, etc. with accu-



racy. Employs null-balance differential-transformer system actuated by 2-phase motor. Has full-range rotation

ENGINEER WANTED BOSTON AREA

We are seeking an engineer who has shown ingenuity in the field of small electro-mechanical devices, switches, relays and the like, and who is able to analyze the electronic circuits in which they are used.

The man who can satisfactorily demonstrate his ability to us will qualify for the position of assistant chief engineer in our firm. Formal education is not important to us, but ingenuity is.

The man we want has a strong conviction that his future lies in a company of one hundred employees or less where his work will be seen and will be appreciated.

Our company, located in Boston, is well established and preeminent in its field. Our employees know of this advertisement. If you think you qualify, please telephone our advertising agency, Hancock 6-3565, who will arrange for an interview with our chief engineer, or write Box 205, Instruments Publishing Co., 921 Ridge Ave., Pittsburgh 12, Pa.

"the 'bible' of flow measurement"

"PRINCIPLES AND PRACTICE OF FLOW METER ENGINEERING"

by L. K. Spink

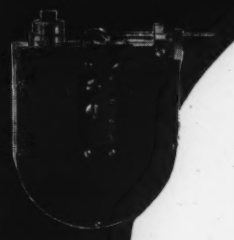
New, greatly enlarged seventh edition of the book which, for over twenty years, has been used throughout the civilized world as the standard comprehensive text on flow measurement. Contains much new reference and instructional material. 418 pages.

$7.00 postpaid

Send check, money order, or purchase requisition to

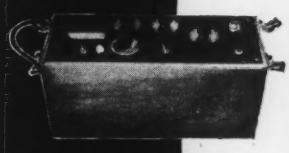
THE FOXBORO COMPANY
Foxboro, Massachusetts, U.S.A.

Edin instruments



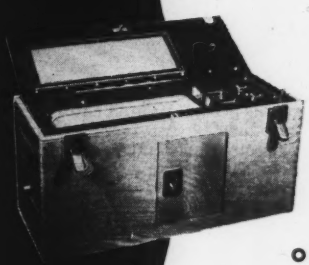
OSCILLOGRAPH GALVANOMETER

No's. 8001, 8002, 8003 and 8004 ink-writing galvanometers have sensitivities from 3.5 to 40 volts per cm., resonant frequencies from 15 to 120 cps., resistances from 1000 to 2000 ohms, frequency response up to 350 cps., and a single-jewel pivot construction. Units are designed for multiple operation up to 10 channels in a total width of 12 inches.



DIRECT-COUPLED AMPLIFIER

No. 8100 direct coupled amplifier has a voltage amplification of 13,000 with a maximum output of 70 volts. Frequency response from d.c. to 10,000 cps. is flat within 10%. Input impedance is 2 megohms; output impedance is 150 ohms. Input may range from 0.1 mv. to 100 volts. Stability is better than 0.1 mv. per thirty minutes, or 0.5 mv. per day. Attenuator is stepped for factors from 1 to 1000.



OSCILLOGRAPHS

Recorders can be supplied with 1, 3 or 9 chart speeds ranging from 0.1 mm./sec. to 250 mm./sec. See specifications of OSCILLOGRAPH GALVANOMETER for frequency range.

OSCILLOGRAPH AMPLIFIER

No. 8121 special amplifier has a time constant of 1 second, an exponential response to a square wave at high gain, input impedance of 1 megohm, and input form 0.1 mv. to 1000 volts. At low gain, No. 8121 becomes a DC amplifier with a voltage gain of 100 and an input of 10 mv./mm.

HIGH-GAIN AMPLIFIER

No. 8130 amplifier has a voltage gain of 1,000,000 and includes a built-in pre-amplifier. Frequency response is from 1 to 200 cps. Input may range from 10 microvolts to 100 millivolts. This amplifier is particularly suited for Biological studies.

Many other types of recording and amplifier circuits are available and special equipment can be assembled to meet particular specifications.

EDIN COMPANY, INC.
207 Main Street
Worcester 8, Mass.

Please send complete information on:

- ☐ RECORDERS
- ☐ NO. 8121 AMPLIFIER
- ☐ GALVANOMETERS
- ☐ No. 8100 AMPLIFIER
- ☐ No. 8130 AMPLIFIER
- ☐ ..... SPECIAL (Enclose details)

..... (NAME)

..... (NO.) (STREET)

..... (CITY) (STATE)

..... COMPANY POSITION

Get Truscale For Accurate Liquid Level Indication Down Where You Can See It

Get This New Catalog of JERGUSON TRUSCALE REMOTE READING GAGES

JERGUSON Truscale Gages are virtually indispensable protection for boilers, storage tanks and processing equipment. A single error in reading liquid level can prove very expensive. Jerguson Truscale Gages forestall errors by bringing the reading down to eye level where your operator can see it and properly protect your equipment.

Amazingly accurate, the Jerguson Truscale Gage records liquid level at remote points with accuracy as close as ½ of 1% of scale reading; has built-in adjustment for easy calibration for any specific gravity or W.S.P.; has standard ranges up to 100″; internal moving parts of stainless steel; visible and audible alarm systems; illuminated dial; scale markings and pointer that glow in the dark; and is available with auxiliary repeaters.

The new Jerguson catalog, profusely illustrated, tells in compact, easy-to-read form how Jerguson Truscale Gages operate . . . and why they are the best and the most dependable for your remote reading needs.

Send now for your copy of the new 8-page Jerguson Truscale Gage catalog. Write today.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Fellsway, Somerville 45, Mass.

Representatives in Major Cities

Phone Listed Under JERGUSON

In Europe: Bailey Meters & Controls, Ltd.

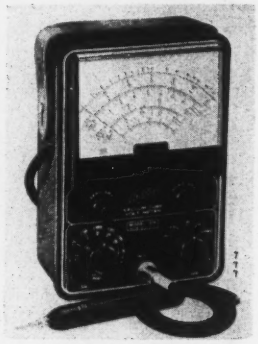
NEW INSTRUMENTS

in 2, 4, or 10 sec.; instantaneous output shaft movement per change; dead beat non-cyclic response. Positions with accuracy of 0.2 percent full range of output shaft. Available in right and left hand assemblies.—*Automatic Temperature Control Co., Inc.*, 5200 *Pulaski Ave., Philadelphia* 44, *Penna.*

Mention No. 123 when filling out card.

VTVM

New "Model 215" vacuum-tube voltmeter has 7 d-c. and a-c. voltage scales: 0-1.5, 3, 12, 30, 120, 300, and 1200 volts. Also peak-to-peak a-c. scale. D-c. input



resistance is 10 megohms; a-c. is 30 megohms with 150-uuf. shunt. Frequency response is flat from 40 cps. to 3.5 Mc. Ohmmeter has 7 scales from x1 ohm to x1 megohm. Weight is 4.5 lbs. —*The Hickok Electrical Instrument Co.*, 10519 *Dupont Ave., Cleveland* 8, *Ohio.*

Mention No. 124 when filling out card.

Oscilloscope

New "TEC Model T-601B" 5-inch oscilloscope provides Y-axis response within 3 db. from 2 cycles to 12 Mc. at 10 millivolts rms. per inch deflection-sensitivity. Sweep generator provides

either recurrent sweeps from 10 cycles to 100 kc. or triggered sweeps from 5 to 10^5 microseconds. Phasing is provided for 60-cycle sweeps; all sweeps may be synchronized to either positive or negative peaks. New features include front-panel availability of sweep sawtooth and retrace pulses.—*Television Equipment Corp.*, 238 *William St., New York* 38, *N. Y.*

Mention No. 125 when filling out card.

Pulse Generator

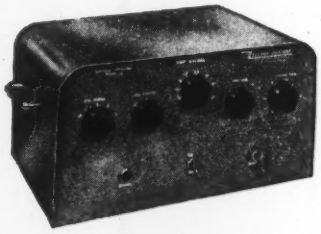
New "Model 503 Fast-Rise Pulse Generator" produces rectangular pulse having rise time less than 10^{-9} sec. Width of pulse is controlled by external "width" cable, and can be as

short as 2×10^{-9} sec. Pulse amplitudes from 0.1 to 100 volts, of either polarity, can be selected. Single pulse, controlled by external trigger, or internally controlled repetitive pulses, with rep. rates from 50 to 150 per sec. can be produced.–*Dept. I., Spencer-Kennedy Laboratories, Inc.*, 186 *Massachusetts Ave., Cambridge* 39, *Mass.*

Mention No. 126 when filling out card.

D-c. Amplifier

New "Model 14 D.C. Beaker Amplifier" is claimed to have "lowest noise level and highest zero stability . . . commercially available." Furnished with



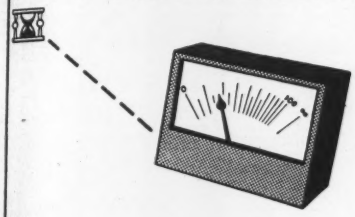
input resistance from 5 to 100,000 ohms. Uses 8-cycle chopper. Noise level is within a factor of two of theoretical limit. Drift is less than 0.005 microvolt in 8 hrs. Has coarse and fine grain controls and two bucking zero-set controls. Weight is 40 lbs.—*Liston-Becker Instrument Co., Inc.*, 20 *Beckley Ave., Stamford, Conn.*

Mention No. 127 when filling out card.

Low-resistance Ohmmeter

New "Megger" low-resistance ohmmeter is completely self contained and has a range of 0 to 1000 and 0 to 10,000 microhms. "Model 1 B" is bat-

R C INTERVALOMETER



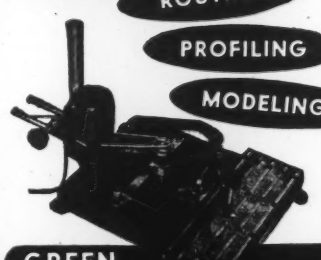
intervals

MEASURED PRECISELY!!

0.5μ SEC.
TO
0.1 SEC.

NELSON & STREET
P.O. BOX 4342 TAKOMA PARK
WASHINGTON 12, D.C.

ENGRAVING
ROUTING
PROFILING
MODELING



GREEN ENGRAVER
Proved Profitable —
Machine Tool, Radio, Electrical and Instrument Mfrs., Sales Promotion and Advertising.

Fast, rugged, convenient—and **inexpensive.** The Green Engraver is tops for low-cost performance—zips out **precision** work on metal, plastics or wood . . . cuts four lines of letters from 3/64" to 1" on curved or flat surfaces . . . operates by tracing . . . makes anyone an expert . . . engraves panels, name plates, scales, dials, molds, lenses and instruments. (Also widely used for routing, profiling, and three dimensional modeling.) Electric etching attachment available.

Special attachments and engineering service available for production work.

FREE—Fact-packed folder. Send for yours, today.

GREEN INSTRUMENT CO.

GREEN — 383-B Putnam Avenue, Cambridge, Mass.

● MORE THAN 27,000

THERE IS AN EASY WAY TO CONTROL VIBRATION

The easiest way to solve your vibration problem is to put it up to your nearest Lord Field Engineer. He will analyze it and recommend the specific type of Lord Mounting necessary. By drawing upon complete data files of more than 27,000 Lord Mountings and their variations, it is probable that he can solve your problem from this reservoir of available Lord Mountings.

If your vibration trouble involves circumstances which have not been encountered before, your Lord Field Engineer will work closely with you and with engineers at the Lord Factory to design the type of specific Lord Mounting most profitable to you.

For immediate attention to your problem call or write to

BURBANK, CALIFORNIA
Joe B. Hartley
George E. Behlmer
233 South Third Street
ROckwell 9-2151
CHarleston 6-7481

CHICAGO 11, ILLINOIS
Robert T. Daily
Kenneth L. Hanson
Perry C. Goodspeed, Jr.
520 N. Michigan Ave.
MIchigan 2-6010

DALLAS, TEXAS
Bruce O. Todd
1613 Tower Petroleum Building
PRospect 7996

DAYTON 2, OHIO
W. Webster Dalton
238 Lafayette Street
MIchigan 8871

DETROIT 2, MICHIGAN
Everett C. Vallin
7310 Woodward Ave.
TRinity 5-8239

NEW YORK 16, NEW YORK
Vincent Ellis
Jack M. Weaver
280 Madison Avenue
MUrray Hill 5-4477

PHILADELPHIA 7, PENNSYLVANIA
George P. Harrington
725 Widener Building
LOcust 4-0147

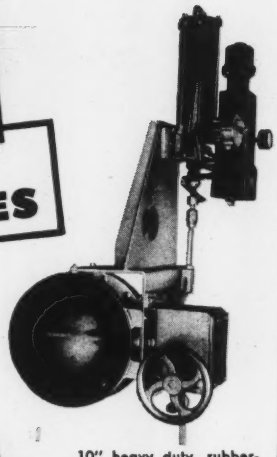
ERIE, PENNSYLVANIA
Paul E. Dailey
Harry C. Sapper
1635 West 12th Street
2-2296

LORD MANUFACTURING COMPANY • ERIE, PA.

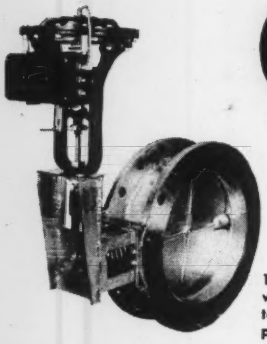
LORD BONDED RUBBER — HEADQUARTERS FOR VIBRATION CONTROL MOUNTINGS . . . BONDED RUBBER PARTS

For Air • Steam • Water
Hot • Abrasive • Corrosive
Gases, Liquids, Semi-Solids

Install
ROCKWELL VALVES



- Manual or Automatic Control and Quick, Tight Shut-Off
- Made of any metal or rubber-lined
- Butterfly, Wafer Butterfly and Slide Valve Types, Threaded or Flanged
- Pipe sizes to 72" and larger



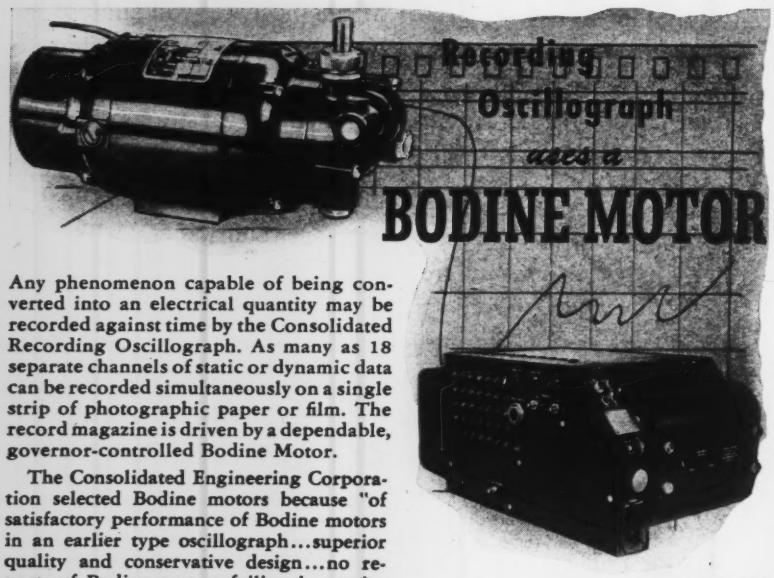
10" heavy duty, rubber-lined steel butterfly valve for 90 p.s.i.; with air cylinder controller and auxiliary clutch and handwheel.

18" alloy steel butterfly valve for 1100° F. operating temperature; with air diaphragm operator and valve positioner.

Write for Catalog and "The Valve News"

ROCKWELL SINCE 1888 BUILT

W. S. ROCKWELL COMPANY
Slide and Butterfly Valves • Steam Traps • Oil Burners
264 Eliot Street • Fairfield, Conn.



Any phenomenon capable of being converted into an electrical quantity may be recorded against time by the Consolidated Recording Oscillograph. As many as 18 separate channels of static or dynamic data can be recorded simultaneously on a single strip of photographic paper or film. The record magazine is driven by a dependable, governor-controlled Bodine Motor.

The Consolidated Engineering Corporation selected Bodine motors because "of satisfactory performance of Bodine motors in an earlier type oscillograph...superior quality and conservative design...no reports of Bodine motors failing in service ...fine co-operation and ability of sales and engineering staff."

The right motor can add sales appeal and customer satisfaction to your product. It will pay you to consult Bodine engineers.

OUR REPRESENTATIVES
THOMAS R

BODINE
Fractional Hp Electric
MOTORS
BODINE

Bodine Electric Co., 2244 W. Ohio St., Chicago 12, Ill.

THE POWER BEHIND THE LEADING PRODUCTS

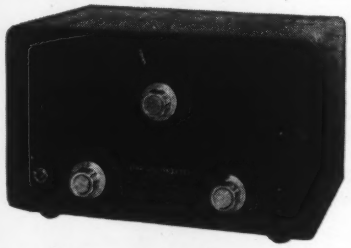
NEW INSTRUMENTS

tery-powered set which employs 2 "4 FH" dry cells, or equivalent. "Model 1R" is a-c. operated. Weight is about 19 lbs.—*James G. Biddle Co.*, 1316 *Arch St., Philadelphia 7, Penna.*

Mention No. 128 when filling out card.

Low-frequency Oscillator

New "Model 400-A Ultra-Low-Frequency Oscillator" provides sine and square-wave voltages at any frequency



between 0.009 and 1,100 cps. Uses RC-bridge sine-wave oscillator. Features include low hum and distortion, excellent amplitude constancy, and single-scale logarithmic dial with vernier.—*Krohn-Hite Instrument Co.*, 580 *Massachusetts Ave., Cambridge* 39, *Mass.*

Mention No. 129 when filling out card.

Dual Regulated Power Supply

New "Model D6" heavy-duty supply provides two regulated outputs variable from 0 to 600 v. at a max. current of 200 ma. each, with regulation better

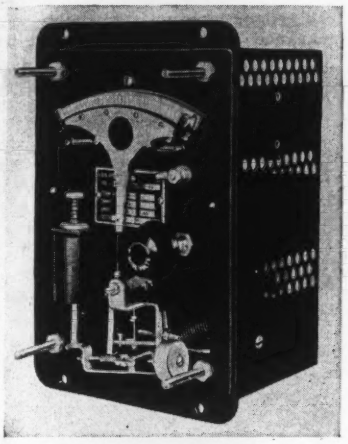
than 0.5 percent and ripple less than 10 mv. Knob combines two outputs to give max. output of 400 ma. Other outputs are 6.3 v. a.c. at 10 amp. center-

tapped, 650 v. d.c. unregulated with less than 2 volts ripple, 0 to 150 v. d.c. at 5 ma. variable and stabilized. Voltmeter and milliameter monitor outputs. —*Oregon Electronic Mfg. Co., 2232 E. Burnside St., Portland 15, Ore.*

Mention No. 130 when filling out card.

Voltage Regulator

New "Rocking Contact" voltage regulator for small a-c. generators is available in two ratings—"Type V-00" has 34-step commutator; "Type 221" has



50 steps. Former has max. rating of 157 kva. at 3600 rpm., latter is 438 kva. at 3600 rpm. Has built-in voltage-adjusting rheostat and is dust-proof. Hunting is prevented by damping system. Rocking contact maintains constant generator voltage by changing resistance in exciter shunt field circuit. —*Allis-Chalmers Mfg. Co., 942 S. 70th St., Milwaukee, Wis.*

Mention No. 131 when filling out card

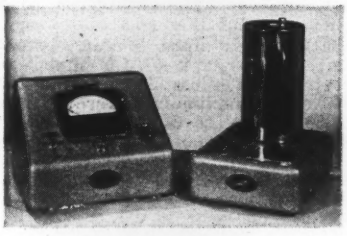
Beta-ray Applicator

New instrument contains Strontium-90 radioactive isotope for treating corneal ulcers and other eye conditions. Rays penetrate flesh only to depth of 3.9 mm. so that delicate inner structure of eye is not endangered.—*Tracerlab, Inc., 130 High St., Boston 10, Mass.*

Mention No. 132 when filling out card.

Gamma Radiation Meter

New "Model AH Gammometer" has ranges of 0.1 microcurie, 1 microcurie, 10 microcuries and 100 microcuries of radium. Can be calibrated in milliroentgen per hour. Precision is 1 percent full scale; calibration accuracy is 5 percent. Consists of cell box and indi-



The control console

A bank of 84 Struthers-Dunn Type 112XAX relays that control indicating lights corresponding to the alarm code.

432 S-D relays help Philadelphia report "*Fire!*" in 8 seconds

In 8 seconds after the alarm box lever has been pulled, the Quaker City's new fire reporting system receives alarms from 3200 local boxes and dispatches them to the proper fire house and its alternates. Designed by Philadelphia Electrical Bureau engineers, this intricate installation—the most modern of its kind in the world—uses 432 standard Struthers-Dunn relays. Since July 1949, these relays have been in constant service and not one has required adjustment, cleaning or service of any kind.

STRUTHERS-DUNN

5,348 RELAY TYPES

STRUTHERS-DUNN, INC., 150 N. 13th ST., PHILADELPHIA 7, PA.

BALTIMORE • BOSTON • BUFFALO • CHARLOTTE • CHICAGO • CINCINNATI
CLEVELAND • DALLAS • DETROIT • KANSAS CITY • LOS ANGELES
MINNEAPOLIS • MONTREAL • NEW ORLEANS • NEW YORK • PITTSBURGH
ST. LOUIS • SAN FRANCISCO • SEATTLE • SYRACUSE • TORONTO

NOW! ELECTRO-TECH'S

OFF-THE-SHELF SERVICE

can save months on your schedule

ONE SOURCE OF SUPPLY for all kinds of ELECTRICAL METERS, INSTRUMENTS and INDUSTRIAL CONTROLS

No need to hold up production for lack of a meter, controller or other instrument! Electro-Tech's warehouse is bulging with panel meters, solenoids, transformers, rectifiers, timers, counters and every other kind of meter and control device.

Plus—complete laboratory facilities to convert, repair and re-scale stock meters and instruments to fit your needs.

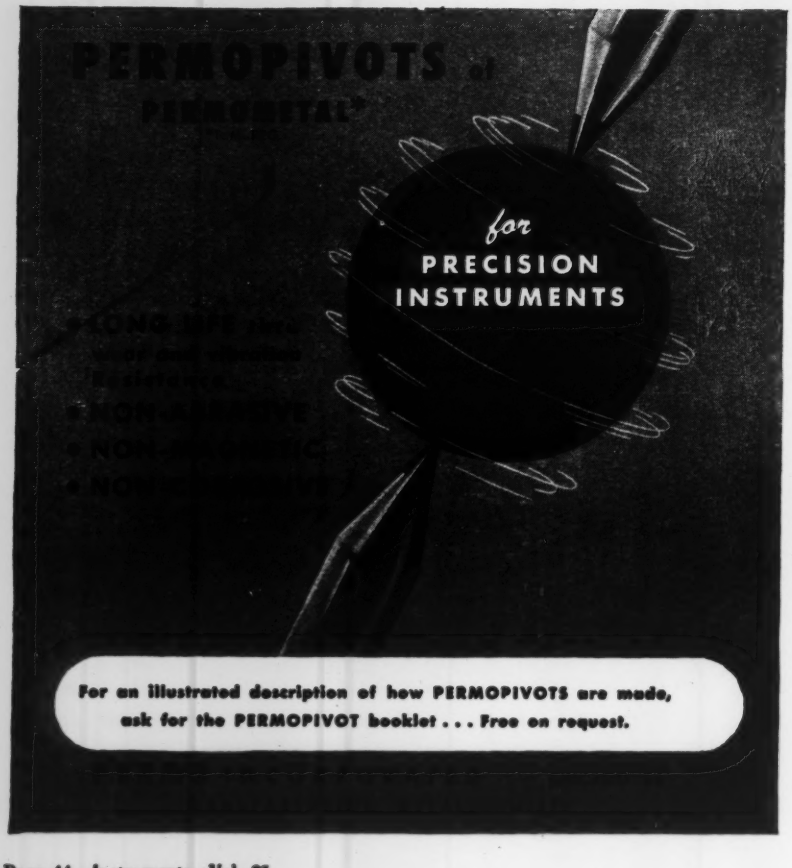
- SIMPSON
- WESTON
- STRUTHERS-DUNN
- MICRO SWITCH
- SUPERIOR ELECTRIC
- GENERAL ELECTRIC
- WHEELCO

— and others

FREE! *Write today for the big, useful Electro-Tech BUYER'S GUIDE.*

ELECTRO-TECH
EQUIPMENT COMPANY, Dept. 1-2
308 Canal Street, New York 13, N.Y.

ELECTRO-TECH



For an illustrated description of how PERMOPIVOTS are made, ask for the PERMOPIVOT booklet . . . Free on request.

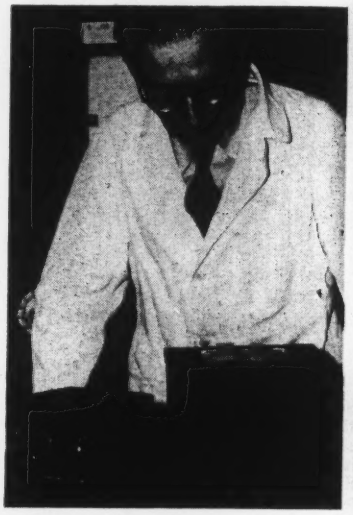
NEW INSTRUMENTS

cator unit. Cell box contains electrometer tube and new "Ohmart" cell which converts radioactive energy directly into electrical energy. Thus no high-voltage power supply is required.—*The Ohmart Corp., 2347 Ferguson Rd., Cincinnati 38, Ohio.*

Mention No. 133 when filling out card.

Glass Dosimeter

New colorless glass containing dissolved silver remains unchanged in appearance under ordinary light, but



reveals extent of exposure to X or gamma rays by amount of orange fluorescence emitted when viewed under ultraviolet. Is sensitive to small amounts of radiation—as low as 10 roentgens.—*Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.*

Mention No. 134 when filling out card.

Proportional Counter

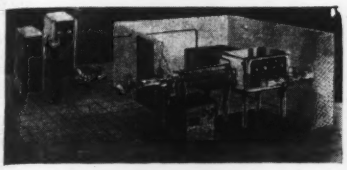
New "Model PC-2B" alpha-beta-gamma proportional counter counts soft betas. Counts betas in presence of alphas without absorbers, and alphas in presence of betas. Specifications include

—background: alpha 5 c/hr.; beta 45 c/m; geometry: 2 pi for alpha and beta; resolution loss: 1 percent per 100,000 c/m; maximum counting rate: 15,000 c/m; plateaus: alpha, 1000 v. to 1300 v.; beta 1600 v. to 1900 v; register: six-digit with reset.—*Nuclear Measurements Corp., Indianapolis 18, Ind.*

Mention No. 135 when filling out card.

Particle Accelerator

New particle accelerator of "Cockroft-Walton" type operates at voltages up to 250 kilovolts and produces intense beam of charged particles. Delivers focused beam concentrated in a circle

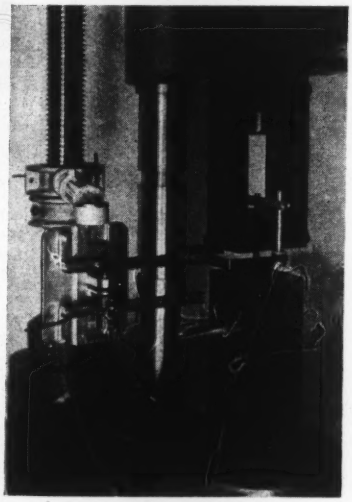


smaller than 1 mm. diam. Beams of larger area may be obtained. R-f. ion source operates with hydrogen, deuterium, helium, argon, and xenon. Accelerating system is horizontal, 10-feet long, and is mounted on wheeled carriage. Requires no special building facilities and may be operated in a room 12-ft. wide by 18-ft. long. Vacuum system produces equilibrium vacua of better than 10^{-6} mm. mercury with no beam, and 3 x 10^{-6} mm. mercury with beam.—*American Instrument Co., Inc., Silver Spring, Md.*

Mention No. 136 when filling out card.

Bolt Extensometer

New bolt extensometer, for tensional tests of bolts without influence of shifting of grips or seating of specimen, contacts center of ends of bolt to meas-



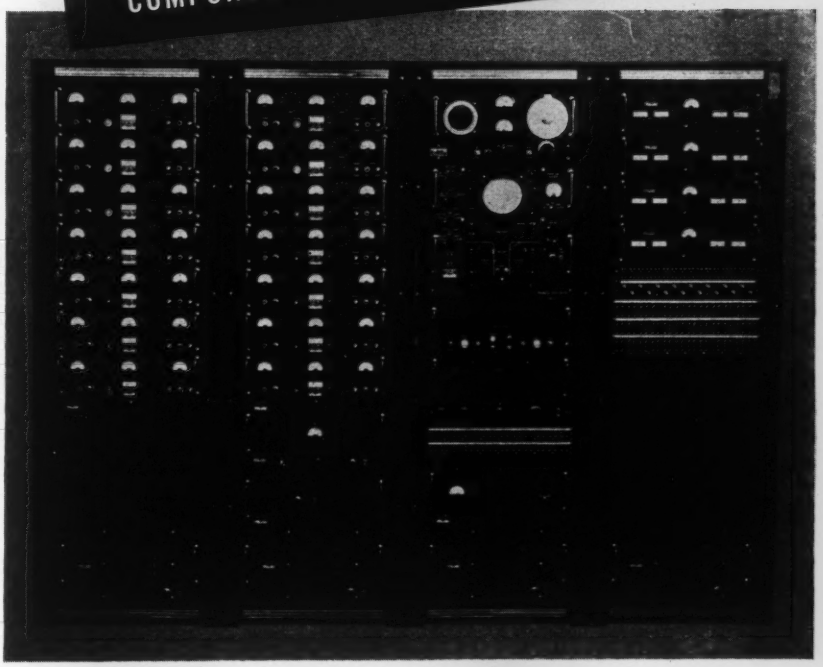
ure elongation. Extensometer moves core of strain-follower "Microformer"-type variable miniature transformer. Electrical impulse is amplified to drive a servo motor, which moves core of recorder "Microformer." Extensometer has magnifications of 12.5, 25, and 50 to 1.—*Baldwin-Lima-Hamilton Corp., Philadelphia 42, Penna.*

Mention No. 137 when filling out card.

Electron Microscope

New "Model WT-1" is Japanese-made electron microscope of magnetic-field type. Specifications include resolving power of 50 Angstroms; magnification

AVAILABLE WITH VARIOUS STANDARD COMPONENTS TO MEET ANY REQUIREMENT



Typical Bendix 14-band Telemetering Receiving Station. Other standard component configurations can provide for reception of fewer subcarrier bands, or decommutation of up to 27 channels can be added.

Bendix-Pacific

FM/FM TELEMETERING RECEIVING STATIONS

Advanced engineering features in this new equipment combine to produce the highest degree of reliability, accuracy and ease of operation in the reception and recording of telemetering signals.

The stations receive frequency-modulated radio signals employing continuous or commutated subcarriers. Any of the 18 standard subcarrier oscillator bands are available and a maximum of 14 continuous subcarriers can be received and recorded simultaneously by means of standard plug-in assemblies. Up to 27 signal channels can be separated from commutated subcarriers with each signal being recorded as a continuous trace. Reliability is assured by circuits which maintain synchronization even in the presence of noise or failure of an individual telemetering channel.

The equipment is designed to provide long life under continuous operation. Special attention has been given to ease of operation and service in the field.

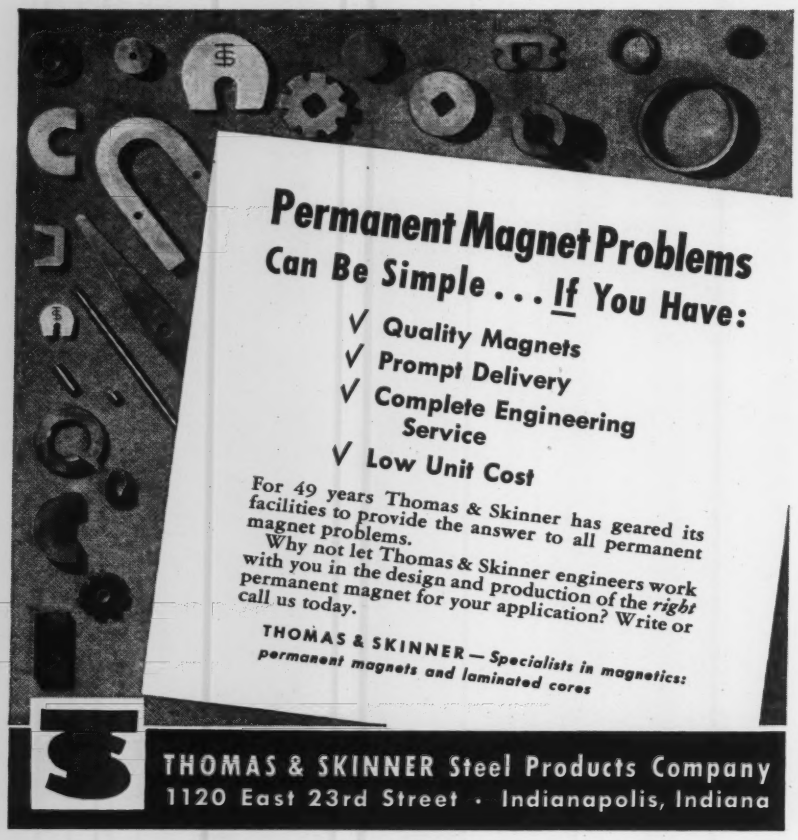
Write for complete information

Bendix

Pacific Division

Bendix Aviation Corporation

TO MEASURE..TO WARN..TO INDICATE..AT A DISTANCE


Permanent Magnet Problems
Can Be Simple . . . If You Have:
✓ Quality Magnets
✓ Prompt Delivery
✓ Complete Engineering Service
✓ Low Unit Cost
For 49 years Thomas & Skinner has geared its facilities to provide the answer to all permanent magnet problems.
Why not let Thomas & Skinner engineers work with you in the design and production of the right permanent magnet for your application? Write or call us today.
THOMAS & SKINNER — Specialists in magnetics: permanent magnets and laminated cores
THOMAS & SKINNER Steel Products Company
1120 East 23rd Street · Indianapolis, Indiana

Pneumatic Weight Transmitters

FOR LINEAR CONVERSION OF WEIGHT INTO POUNDS PER SQUARE INCH AIR PRESSURE

A complete line of weight transmitters in single and multiple diaphragm construction with load capacities up to 23,000 pounds per diaphragm. Pneumatic tare balance for any portion of the total load on all models. All moving parts are enclosed totally. Complete weighing systems designed to your requirements.

WRITE FOR CATALOG

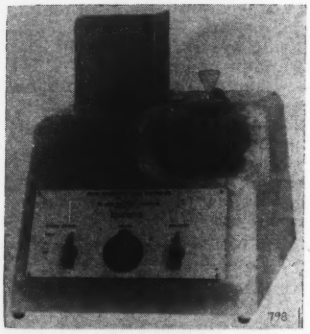
JOHN R. MONSELL
Manufacturing Engineer
Pitman, N. J.

of 100,000X (max. overall); beam current of 10 to 100 ua. Specimen chamber is airlock type. Time for changing specimen is 2 to 3 min. Camera is 85 x 65 mm. Triplet. Power source is 100 v., 50 to 60 cps.—*Electro-Physics Co., 287 Broadway, New York 7, N. Y.*

Mention No. 138 when filling out card.

Flame Photometer

New photometer for analysis of sodium, potasium, calcium, and lithium has accuracy of 0.5 percent. Completely sealed combustion system, using city gas and compressed air, eliminates contamination from laboratory. Sample

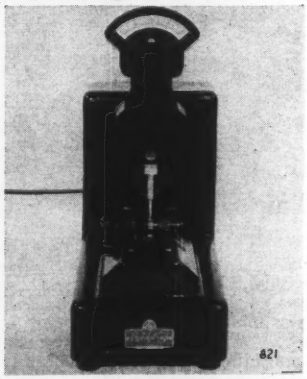


is atomized by compressed air jet and burned with illuminating gas. Flame produced acts as source for two photocells. Operator reads potentiometer setting and determines element concentration by near-linear calibration curves. Precise filters are available for research work in lithium, sodium, and calcium.—*Baird Associates, Inc., 33 University Rd., Cambridge 38, Mass.*

Mention No. 139 when filling out card.

Comparator

New "Electrolimit Internal Clearance Comparator, Lever Type" gages precision instrument-type bearings. Handles bearings from 3/32 to ½ in.

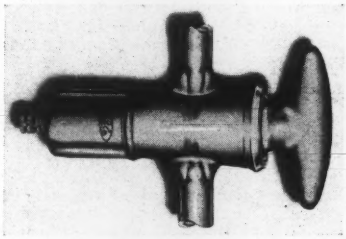


bore. C-shaped sub-assembly with arbor holds bearing vertically by inner ring. Diamond-tipped gaging spindle bears against outer bearing ring. Difference between two readings represents amount of radial clearance in bearing assembly.—*Pratt & Whitney, Div. of Niles-Bement-Pond Co., West Hartford 1, Conn.*

Mention No. 140 when filling out card.

Stopcock Adapters

New stopcock adapters in 3 sizes cover range from 2 mm. to 15 mm. Designed for laboratory technicians who

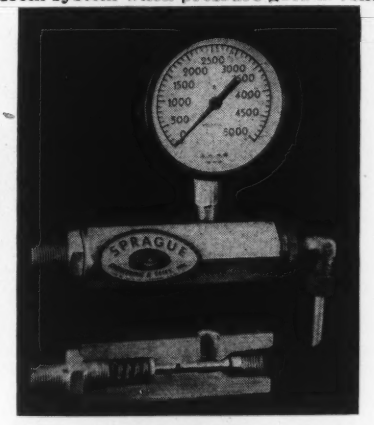


require pressure stopcocks for burets, gas sampling, etc. Manufactured of corrosion-resistant materials, adapters eliminate special pressure stopcocks.—*Emil Greiner Co., 20-26 N. Moore St., New York 13, N. Y.*

Mention No. 141 when filling out card.

Shut-off Valve

New shut-off valve for pneumatic and hydraulic systems cuts out gages from system when pressure goes beyond

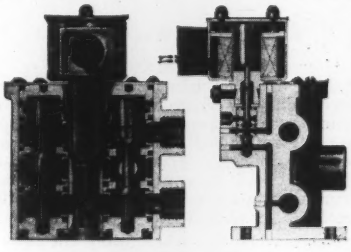


gage limit, and opens gage to system when pressure is again within operating range. Available for low pressure (30 to 300 psi.) and high-pressure (500 to 5000 psi.). Compression spring controls shut-off point. Minor adjustments can be made by screw; major changes by replacing compression spring.—*Sprague Engineering & Sales Corp., Gardena, Calif.*

Mention No. 142 when filling out card.

Four-way Valves

New "Crescent" line of 4-way valves features continuous fast cycling, up to 600 cycles per min. without over heating. Solenoid controls pilot valve which



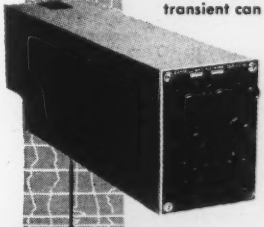
THE HATHAWAY SC-16A SIX ELEMENT
RECORDING CATHODE-RAY
OSCILLOGRAPH

NEW HIGHS IN RESOLUTION are obtained by this new oscillograph because of its unusually HIGH FREQUENCY RESPONSE and HIGH CHART SPEED...designed for recording fast transients and continuous phenomena.

FREQUENCY RESPONSE 0 to 200,000 cycles per second
RECORDS up to 1000 ft. long at speeds up to 600 inches per second
RECORDS up to 10 ft. long at speeds up to 6000 inches per second
WRITING SPEED as high as 5,000,000 inches per second

Note these additional unusual features.

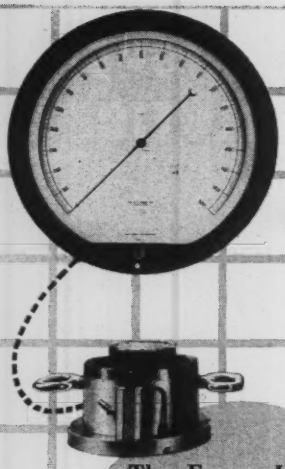
- SIX ELEMENTS with convenient interchangeable lens stages for 1, 2, 3, or 6 traces on full width of chart.
- INTERCHANGEABLE RECORD MAGAZINES for CONTINUOUS RECORDING on strip chart, either 6 inches or 35mm in width up to 1000 feet in length, DRUM RECORDING for short, high-speed records, and STATIONARY CHART for very short transients.
- PRECISION TIMING EQUIPMENT, tuning fork controlled, for 1-millisecond or 10-millisecond time lines.
- Crystal-controlled Z-AXIS MODULATION for 1/10 millisecond time marks.
- QUICK-CHANGE TRANSMISSION for instantaneous selection of 16 record speeds over a range of 120 to 1.
- AUTOMATIC INTENSITY CONTROL.
- CONTINUOUS SWEEP OSCILLATOR which permits viewing as well as recording.
- Single-pulse LINEAR OSCILLATOR for recording transients on stationary film. The record can initiate the transient to be recorded, or the transient can initiate the record.



Each recording element is a complete unit, fully housed, which can be instantly inserted or removed. Recording element contains high-intensity cathode-ray tube, and both AC and DC amplifiers. Control panel is located on outside end.

FOR FURTHER INFORMATION, WRITE FOR BULLETIN 2 G-1-H

Hathaway
INSTRUMENT COMPANY
1315 SO. CLARKSON STREET • DENVER 10, COLORADO



force measuring system

uses

HEISE GAUGES

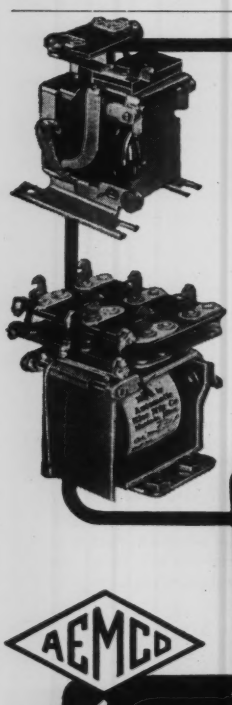
for

- EXTREME ACCURACY
- STABILITY
- SERVICE

The Emery Hydraulic Weighing System measures forces in materials testing machines, in testing jet engine thrust and dynamometer torque, and in other special force problems. In these exacting applications, Heise Bourdon Gauges indicate loads to an accuracy of 1/10 of 1% of capacity.

Heise Gauges are used in many industries for precise measurements of pressure. Custom-built in pressure ranges from 0-15 to 0-10,000 psi. Sizes: 8½", 12", and 16" diameter. Prices from $151.60 to $211.20. Write for catalog.

Heise Bourdon Tube Company, Inc.
Newtown, Connecticut



RELAYS *and* TIME SWITCHES

of Diamond AEMCO *Quality*

Open Type
"Can" Type
With Plug-in
Tube Base
A. C. or D. C.
Midget Relays
Dual Purpose
Relays
Delayed
"Make" or "Break"
Automatic
Circuit Control
"Current" and
"Potential" Relays

Ruggedly constructed to exacting specifications that are carefully engineered to provide ample safety factor . . . quality all the way through!

Automatic's relays are not built to a price but to an unexcelled standard of performance. That's why they are the choice of so many "big name" manufacturers.

We engineer and build a wide variety of stock model relays for practically all applications. A staff of competent engineers will design and build relays to fit *your* requirements.

Stock models or custom built, every relay we manufacture will deliver the same dependable performance that has made the "Diamond Seal" line the choice of those who measure *quality* by *performance*.

TIME SWITCHES — Equipped with Synchronous Self-Starting Motors and Silver Contacts.

For any load, for every installation, look to Automatic for the finest in Time Switches and Interval Timers.

WRITE FOR CATALOG

AEMCO

Automatic Electric **MFG. CO.**

58 STATE STREET · MANKATO, MINN.

NEW INSTRUMENTS

controls ports to cylinder. Valve sizes are ¼, ⅜, ½ and ¾ inch for single- and dual-pressure operation on air, water, or oil from 0 to 150 psi. A-c. and d-c. solenoids available.—*Barksdale Valves, 1566 E. Slauson Ave., Los Angeles 1, Calif.*

Mention No. 143 when filling out card.

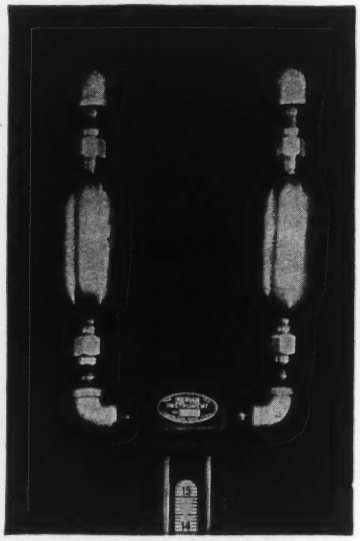
Flow-control Valve

New flow-control valve, for air and hydraulic cylinder speed-control is made with "Dryseal" pipe threads to eliminate leakage at connection. Valves, incorporating floating ball check, are available in 5 sizes—⅛, ¼, ⅜, ½, and ¾ in.—*Pneu-Trol Devices, Inc., 3122 N. California Ave., Chicago, Ill.*

Mention No. 144 when filling out card.

Mercury Trap

New "Mercureceiver" traps mercury blown from manometers and achieves equilibrium readings in 10 sec. or less. Also dampens surges, filters actuating



media, and prevents loss of mercury. Made of moly or stainless steel. Porosity HX membrane prevents passage of mercury from manometer at pressures under 17 psi. Upstream side has porosity E membrane to prevent entrainment of mercury in effluent gas or liquid and to filter actuating media.—*Chemiquip Co., 6 E. 97th St., New York 29, N. Y.*

Mention No. 145 when filling out card.

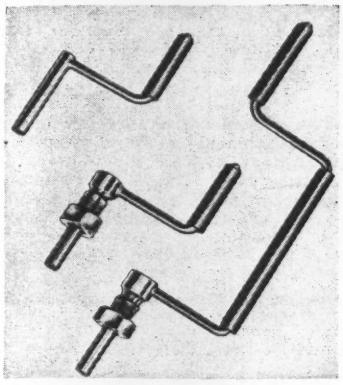
Plastic Drawing Board

New portable drawing board is molded from lightweight Bakelite styrene plastic. Size is 9.75 x 12.25 in. Four corner clamps attach 8.5 x 11 paper. Two metal straight edges, one vertical and one horizontal, are retractable so that triangles can be moved over all four edges of paper.—*A. Partrick Co., 9 Grove St., Westwood, N. J.*

Mention No. 146 when filling out card.

Instrument Winder Crank

New "Winder-Upper" crank is made in three types—key end and crank, torque chuck with a slip-grip, and brace.

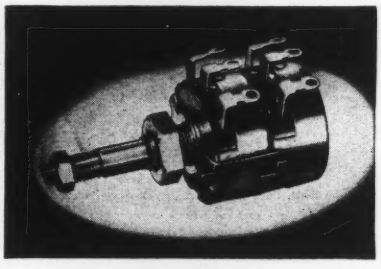


All are chrome plated and eliminate discomfort of keys.—*J. A. Campbell Co., 645 E. Wardlow Rd., Long Beach 7, Calif.*

Mention No. 147 when filling out card.

Shaft Lock

New adaptation for locking shafts at a desired setting is now available on dual-concentric controls. Allows re-

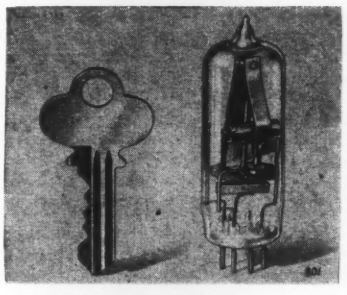


placement of two panel units requiring locked semi-permanent settings and requires one-half panel space of two single units.—*Clarostat Mfg. Co., Inc., Dover, N. H.*

Mention No. 148 when filling out card.

Thermal Timing Relay

New "Model 207" sealed-in-glass miniature thermal relay is hermetically sealed in T-5½ glass envelope with miniature button 7-pin base. Weight is ½ ounce. Delay periods from 5 to 120 sec. Heater voltages are 6.3 v., 27.5 v., and 115 v. a.c. or d.c. Contacts are rated at 2.5 amp. 125 v. a.c. or 1.0



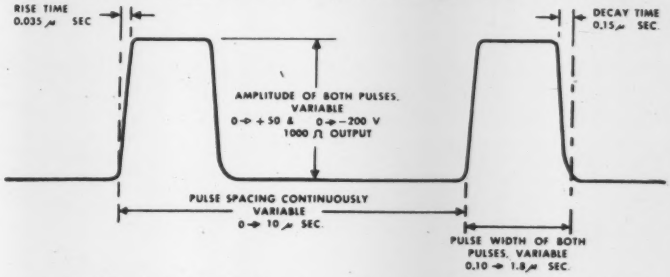
Berkeley

DOUBLE PULSE GENERATOR

DESCRIPTION: The Berkeley Model 903 Double Pulse Generator is a general-purpose laboratory instrument that produces either single or paired pulses. Pulses are individually variable in width, amplitude, and spacing. Pulse polarity is individually selectable. Separate connectors provide impedance levels of 50 or 1,000 ohms for each pulse output.

SPECIFICATIONS

- PULSE DIMENSIONS: Positive or negative as shown below


RISE TIME
0.035 μ SEC
DECAY TIME
0.15 μ SEC
AMPLITUDE OF BOTH PULSES, VARIABLE
0 → +50 & 0 → −200 V
1000 Ω OUTPUT
PULSE SPACING CONTINUOUSLY VARIABLE
0 → 10 μ SEC
PULSE WIDTH OF BOTH PULSES, VARIABLE
0.10 → 1.8 μ SEC

- REPETITION RATE: Internally or externally controlled, 1 to 1,000 cycles. Push button single cycle.
- CALIBRATION ACCURACY: Separation dial, ±5% over entire range.
- INPUT POWER: 105 to 125 volts, 60 cycles, 90 watt.
- DIMENSIONS: 14¼" x 9¾" x 10¾"; panel, 8" x 13".
- NET WEIGHT: 18¼ lbs.
- PRICE: $440 F.O.B. factory.

TYPICAL APPLICATIONS: Checking characteristics of high-resolution electronic circuits, gates, switches, wide-band amplifier, measurement of resolution time of counting circuits, etc.

COMPLETE INFORMATION *is yours for the asking; please request Bulletin 903-I.*

Berkeley Scientific Corporation

2200 WRIGHT AVENUE • RICHMOND, CALIFORNIA

SAY "GOODBYE"

TO BIG PROBLEMS WITH SMALL PARTS

INVESTIGATE

LEVIN

PRECISION JEWELER'S LATHES, ACCESSORIES AND MICRO-DRILL PRESSES

SEND FOR COMPLETE CATALOG

Ideal for second operations or experimental work on small instrument parts where sensitivity is required. Releases expensive, larger lathes for more suitable work. Full line of accessories available.

An extremely sensitive drill press for very small drills down to .002". Drills held in accurate collets to minimize deviation. Spindle run-out less than .0001". Finger tip control enables operator to feel progress of drill.

LOUIS LEVIN & SON, INC.
788 E. Pico Blvd., Los Angeles 21

TANK-O-METER

FOR MEASURING TANK CONTENTS ANY DISTANCE AWAY

ANY LIQUID

Uehling

INSTRUMENT CO.

470 GETTY AVENUE • PATERSON, N. J.

SEND FOR BULLETIN 945

amp. 125 v. d.c. Ambient compensated from minus 60 to plus 85 deg. C.—*Thomas A. Edison, Inc., West Orange, N. J.*

Mention No. 149 when filling out card.

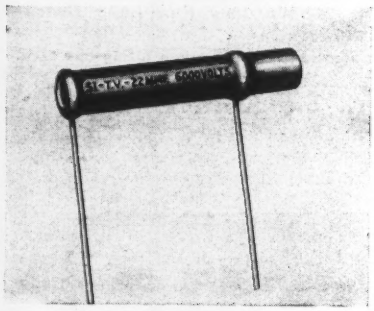
Time-delay Switch

New time-delay control switch for electric solenoid valve controls used with air or hydraulic cylinders, permits time dwell from ¼ to 10 seconds. Time-delay adjustments are made by knurled adjustment screw, which moves switch position in relation to piston lever arm.—*Pneu-Trol Devices, Inc., 1436 N. Keating, Chicago, Ill.*

Mention No. 150 when filling out card.

Hi-voltage Capacitors

New "Type SI-TV" high-voltage tubular ceramic capacitors are high-Q

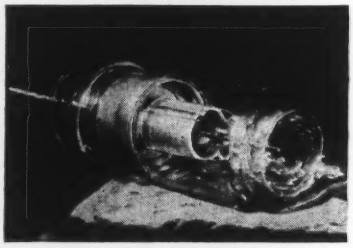


6000-v. capacitors available in eleven capacitance values from 4.7 to 47 uuf.—*Aerovox Corp., New Bedford, Mass.*

Mention No. 151 when filling out card.

Mercury Thyratron

New "Mercury Thyratron MT-1530" is rugged grid-control tube with shielded cathode structure and long life. Fila-



ment requires 5.0 v., 30 amp. Peak anode voltage is 15,000 volts (forward and inverse). Max. plate current is 100 amp. (peak), 15 amp. (average) and 1500 amp. (0.1-sec. surge).—*Sheldon Electric Co., Div. Allied Electric Products, Inc., New York, N. Y.*

Mention No. 152 when filling out card.

Coupling Capacitors

New "Type 502C Shirt-stud" capacitor is tiny ¼-in. diam. ceramic capacitor. Available up to 22 uuf. at 500-v.

PHYSICISTS AND SENIOR RESEARCH ENGINEERS

• • • •

POSITIONS NOW OPEN

• • • •

Senior Engineers and Physicists having outstanding academic background and experience in the field of:

- **Microwave Techniques**
- **Moving Target Indication**
- **Servomechanisms**
- **Applied Physics**
- **Gyroscopic Equipment**
- **Optical Equipment**
- **Computers**
- **Pulse Techniques**
- **Radar**
- **Fire Control**
- **Circuit Analysis**
- **Autopilot Design**
- **Applied Mathematics**
- **Electronic Subminiaturization**
- **Instrument Design**
- **Automatic Production Equipment**
- **Test Equipment**
- **Electronic Design**
- **Flight Test Instrumentation**

are offered excellent working conditions and opportunities for advancement in our Aerophysics Laboratory. Salaries are commensurate with ability, experience and background. Send information as to age, education, experience and work preference to:

NORTH AMERICAN AVIATION, INC.
Aerophysics Laboratory
Box No. R-4
12214 South Lakewood Blvd.
Downey, California

Here's why those in the know

—demand **CANNON PLUGS**

Long rubber bushing lines clamp and shell. Serves as cable relief, gives better insulation.
Molded rubber sleeve for moisture seal. Protects cable entry.
Flat top of steel shell assures correct polarization with finger touch action.
New type thumb latch lock gives smooth action in or out.
Both socket and pin contacts machined from solid brass, gold plated. Hand tinned solder cups.
Rubber cushion at mating face improves moisture protection and insulation.
Spring-loaded insert retainers provide easy insert removal.

The Cannon Electric UA Plug was designed to answer the R. M. A. request for the ideal audio plug. It is the *ultimate* in a quick disconnect for low level sound and related circuits. Incorporating a wealth of design and construction know-how resulting from Cannon's many years of pioneering in this field, the Type "UA" Series typifies the close attention to important detail that distinguishes every type of Cannon Plug—the world's most complete line. The UA Series is sold through selected franchise distributors. Engineering bulletins sent free on request.

The Cannon UA Series consists of 2 plug types and 5 receptacles, all having 3 gold-plated contacts for 15 amp service. Socket contacts are full-floating. The "G" contact engages first, breaks last for "no noise" grounding or shielding purposes.

CANNON ELECTRIC

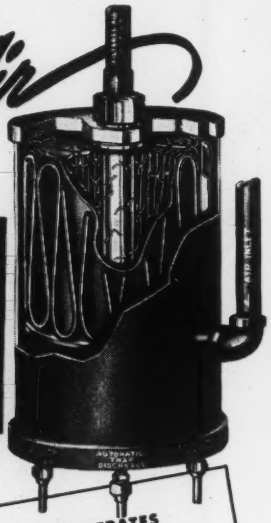
Since 1915

CANNON ELECTRIC COMPANY, LOS ANGELES 31, CALIFORNIA

Factories in Los Angeles, Toronto, New Haven. Representatives in principal cities. Address inquiries to Cannon Electric Company, Department A-180 P. O. Box 75, Lincoln Heights Station, Los Angeles 31, California.

NOW ··· Clean, Dry *Compressed Air*
—for Operating Instruments!

The NEW Model B-30
HANKISON
Condensifilter



For maximum protection of air-operated instruments against oil, water, sludge and foreign materials, the New Hankison Model B-30 Condensifilter features a dehydrating device—a mechanical filter—and a self-purging trap in a single compact unit. Only 15" high and 9" in diameter, this unit will clean and dry compressed air at the rate of 30 c.f.m. at 100 psi. Larger models available for greater capacities.

To add long life and trouble-free service to your air-operated instruments—specify B-30 Condensifilters for your requirements.

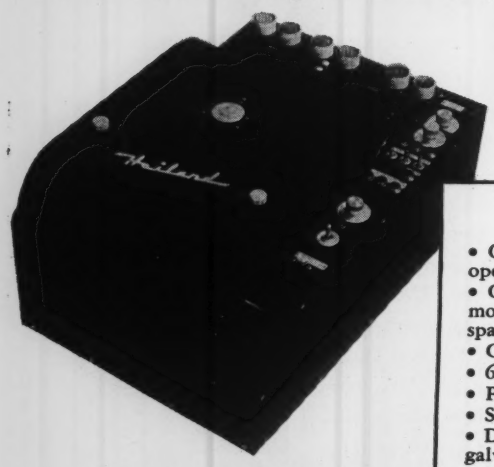
Write today for Bulletin B-30.

HOW IT OPERATES
Compressed air is dried as it crosses coils . . . condensate drops into automatic trap below. Dried air is then cleaned through seven layers of canton flannel, and passed through shaft to the instrument air lines.

HANKISON Corporation
291 Renton Bldg., 1501 Beaver Ave.
Pittsburgh 33, Pa.

Completely Accessible
from operating surface

dependable instruments
Heiland
DENVER



Type A-708...24-channel

AUTOMATIC OSCILLOGRAPH RECORDER

Affording complete accessibility from operating surface and requiring only a minimum of space for mounting, the HEILAND A-708 meets the exacting specifications of research and development personnel in aircraft flight testing, laboratory and industrial testing.

Write for complete details

FEATURES

- Completely accessible from operating surface
- Compact...can be mounted in a minimum of space...lightweight
- Can be panel mounted
- 6 to 24 channels
- Paper widths 5", 8", 12", 18"
- Simplicity of loading
- Direct monitoring of galvonometer light spots
- Flexibility of operation
- Simultaneous viewing, recording and scanning
- Trace identification...zero mirror...synchronizing reference trace
- Adjustable automatic record length

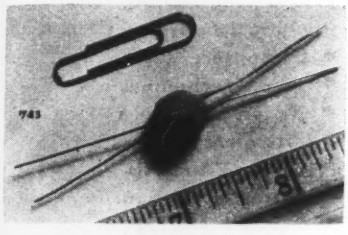
HEILAND RESEARCH CORPORATION • 130 East Fifth Ave. • Denver, Colo.

d-c. working. Performance characteristics are similar to "Sprague Cera-Mite" disc capacitors.—*Sprague Electric Co., North Adams, Mass.*

Mention No. 153 when filling out card.

Miniature Pulse Transformers

New miniature pulse transformers for low-power application weigh less than 0.1 ounce. Built in range from 0.2 to over 5 microseconds pulse widths,

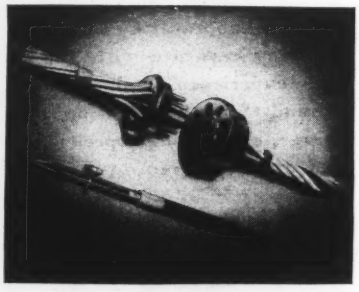


when used as blocking oscillator. Special features are fast rise time with minimum decay. Response from 100 kc. to 30 Mc. can be shifted to higher or lower frequency range as required. Built of class "H" materials for operation at 200 C.—*PCA Electronics, Inc.*, 6368 *DeLongpre Ave., Hollywood* 28, *Calif.*

Mention No. 154 when filling out card.

Octal Connector

New "209FEC" octal-type 9-pin connector and "109C" plug is rugged, small connector with leads attached directly



to contact. Each lead has individual strain relief.—*Alden Products Co.*, 117 *N. Main St., Brockton* 64, *Mass.*

Mention No. 155 when filling out card.

ENGINEERS

wanted at once

LONG-RANGE MILITARY AIRCRAFT PROGRAM

by

NORTH AMERICAN AVIATION, INC.

Los Angeles, California

Columbus, Ohio

Unusual opportunities for Aerodynamicists, Stress Engineers, Aircraft Designers and Draftsmen, and specialists in all phases of aircraft engineering. Engineering skills other than aircraft may be adaptable through paid training program. Also openings for

Recent Engineering College and Technological Graduates

Long-range military program offers fine chance for establishing career in aircraft while aiding defense effort. Transportation and established training time paid. Salaries commensurate with experience and ability.

Please include summary of education and experience in reply to:

Engineering Personnel Office

Section 9

NORTH AMERICAN AVIATION, INC.

Los Angeles International Airport
Los Angeles 45, Calif.

or

Columbus 16, Ohio

BENDIX FRIEZ

Bendix-Friez THERMISTORS

(NEGATIVE TEMPERATURE CO-EFFICIENT CERAMIC RESISTORS)

● These temperature responsive resistors are useful as temperature measuring elements and as liquid level sensors; they are especially well suited to compensation where the circuit constants must be maintained irrespective of temperature changes. Since they are a fired ceramic, they are stable under practically all conditions and respond only to temperature changes.

Many other values can be obtained from standard diameter material. Because the thermistors are made in our own plant, under extremely careful control, special compositions, shapes, and resistance values, hermetically sealed or otherwise protected, can be made in any quantities to suit your individual requirements.

We invite your Inquiries

Write Dept. F

BENDIX-FRIEZ STANDARD ROD TYPES

Size (inches)	@ +30°C.	@ 0°C.	@ −30°C.
.140 x ¾	45 ohms	88 ohms	193 ohms
.040 x 1.5	14,000 ohms	29,946 ohms	74,676 ohms
.018 x 1.5	40,000 ohms	94,040 ohms	262,400 ohms

Typical application in capsule form for temperature sensing of hydraulic oil.

FRIEZ INSTRUMENT DIVISION of
1324 Taylor Avenue • Baltimore 4, Maryland
Export Sales: Bendix International Division, 72 Fifth Ave., N. Y. 11, N. Y.

Bendix AVIATION CORPORATION

PROBLEM

Regardless of the intricacies of an application, you can depend on prompt and thorough evaluation by experienced engineers of — The A. W. Haydon Company

timing

SOLUTION

From problem statement through quantity production, the specialized know-how of The A. W. Haydon Company is devoted to expeditiously fulfilling your requirements.

WRITE FOR CATALOG

The A. W. HAYDON COMPANY
228 NORTH ELM STREET
WATERBURY 20, CONNECTICUT
Design and Manufacture of Electrical Timing Devices

INSTRUMENTS ON THE MARCH

New Principles. Applications. Non-commercial Developments

Precision Thermostat

WASHINGTON, D.C.—An improved precision thermostat (Fig. 1) for temperatures between 1000 and 1550 degrees C. has been developed at the National Bureau of Standards by Dr. Wm. R. Eubank, according to Technical Report 1455. The control provides continuous control of an electric furnace within 0.1 degree C. for several hours, and within 1.0

Fig. 1. Precision thermostat controls temperature of an electric furnace.

degree C. for several days. The furnace winding serves as the sensitive element, forming part of a bridge circuit for control of a thyratron tube (Fig. 2). The thyratron circuit allows just enough current to reach the furnace to compensate for a given temperature fluctuation.

The output of the a-c. bridge, one arm of which serves both as a resistance thermometer and as a heater element

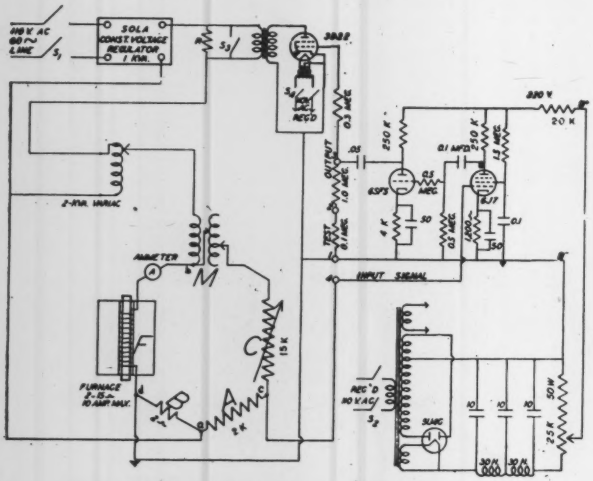


Fig. 2. Circuit diagram of thermostat.

for the furnace, is amplified and applied to the control grid of the thyratron. When the resistance of the furnace winding changes with temperature, the resulting unbalance of the bridge produces a difference in phase between the control voltage and the anode voltage of the thyratron. This phase difference determines the firing period of the thyratron. The thyratron action is reflected to the bridge circuit through a transformer, thus controlling the amount of energy supplied to the furnace.

Electrodynamic VHF Ammeter

WASHINGTON, D. C.—An electrodynamic ammeter employing a short-circuited ring coupled to a coaxial transmission line, has been the subject of a theoretical and experimental study by Max Solow of the National Bureau of Standards, according to Technical Report 1456. The method depends on a torque measurement on a conducting ring immersed in a field which does not change with frequency.

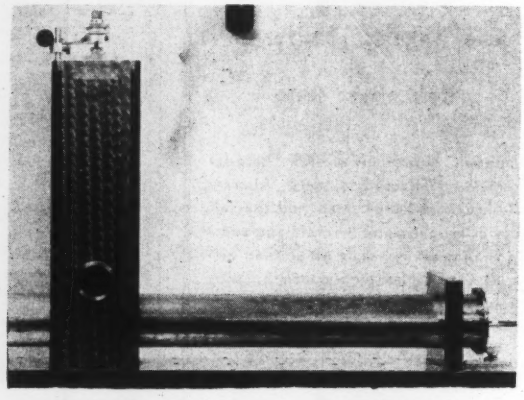


Fig. 1. Electrodynamic ammeter for VHF current.

Fig. 1 shows an experimental model of the electrodynamic ammeter. The horizontal copper tube is the outer conductor of a section of coaxial transmission line. A short-circuited ring, one centimeter in diameter, between the inner and outer conductors of the line, is hung from the tower by a quartz-fiber suspension. Light reflected from a small mirror on the suspension indicates the torque on the ring produced by current in the coaxial line.

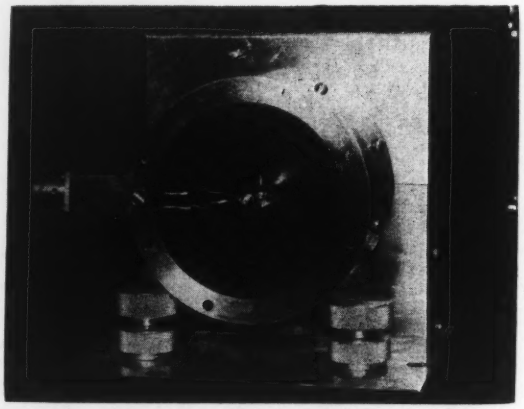
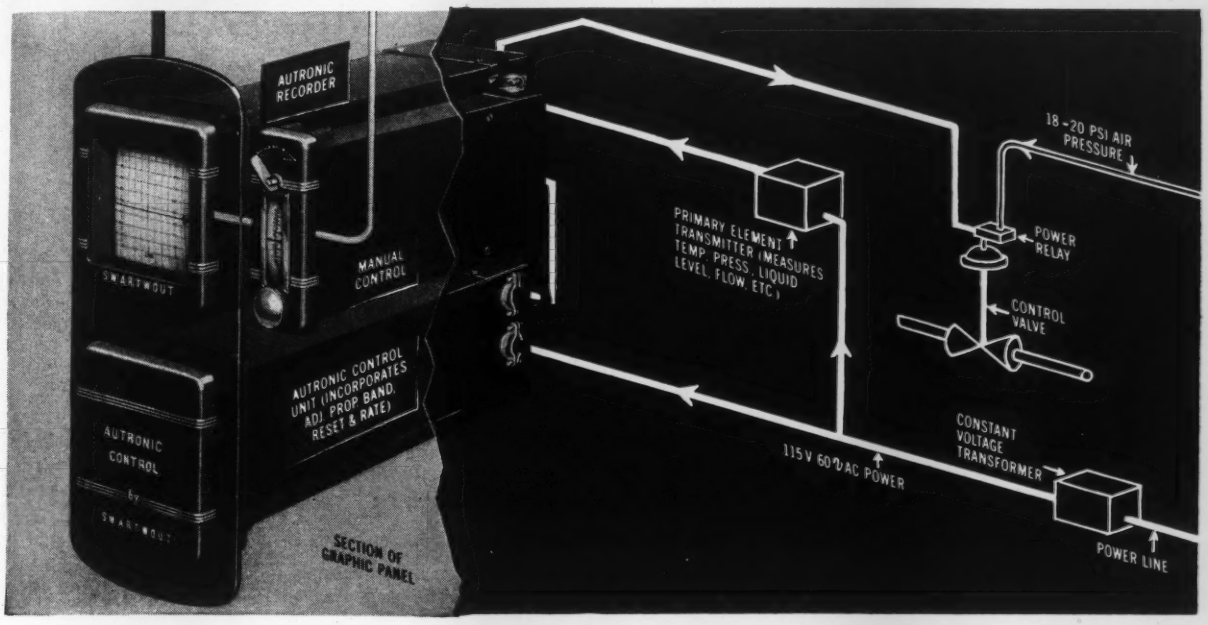


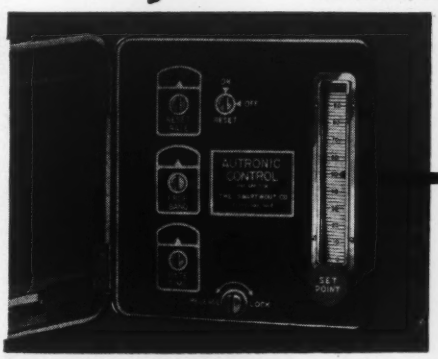
Fig. 2. End view, showing calibrating thermocouple element.

Fig. 2, an end-on view of the VHF electrodynamic ammeter, shows a thermocouple element in place for calibration. The inner conductor of the coaxial line is supported by polystyrene foam, which has a negligible effect on the electromagnetic field. In use, copper plates cover the ends to isolate the ammeter from external fields.

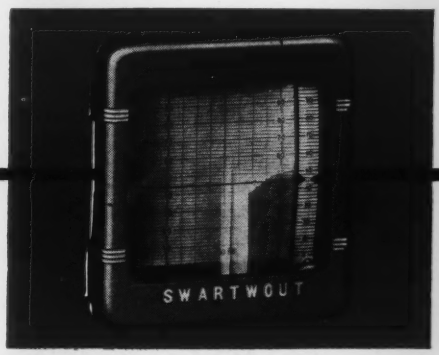
Miniature all-electronic system for instantaneous measurement and control of process variables...



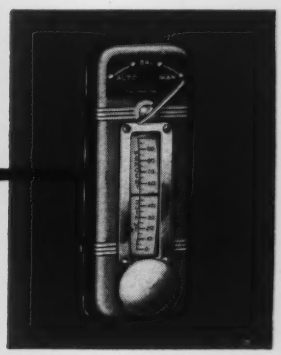
1 Regardless how fast a pneumatic or electro-mechanical system may function, it cannot compare with the *instantaneous, all-electronic* response of the Swartwout Autronic Control System. Here's why. Since transmission of information throughout the system is by *electrical means only*, there is no mechanical motion . . . no slide wires, boosters or motors to initiate control action . . . no control air lines from primary element or to final element. Hence the Autronic Control System *spans distance between primary and final elements without interval* —for closer, more accurate control.



2 **AUTRONIC CONTROLLER,** heart of the system, has no moving parts. Proportion, reset and rate-action adjustments; with or without built-in set-point adjustment. Extremely compact, plug-in type units are interchangeable; can be used direct or reverse-acting.



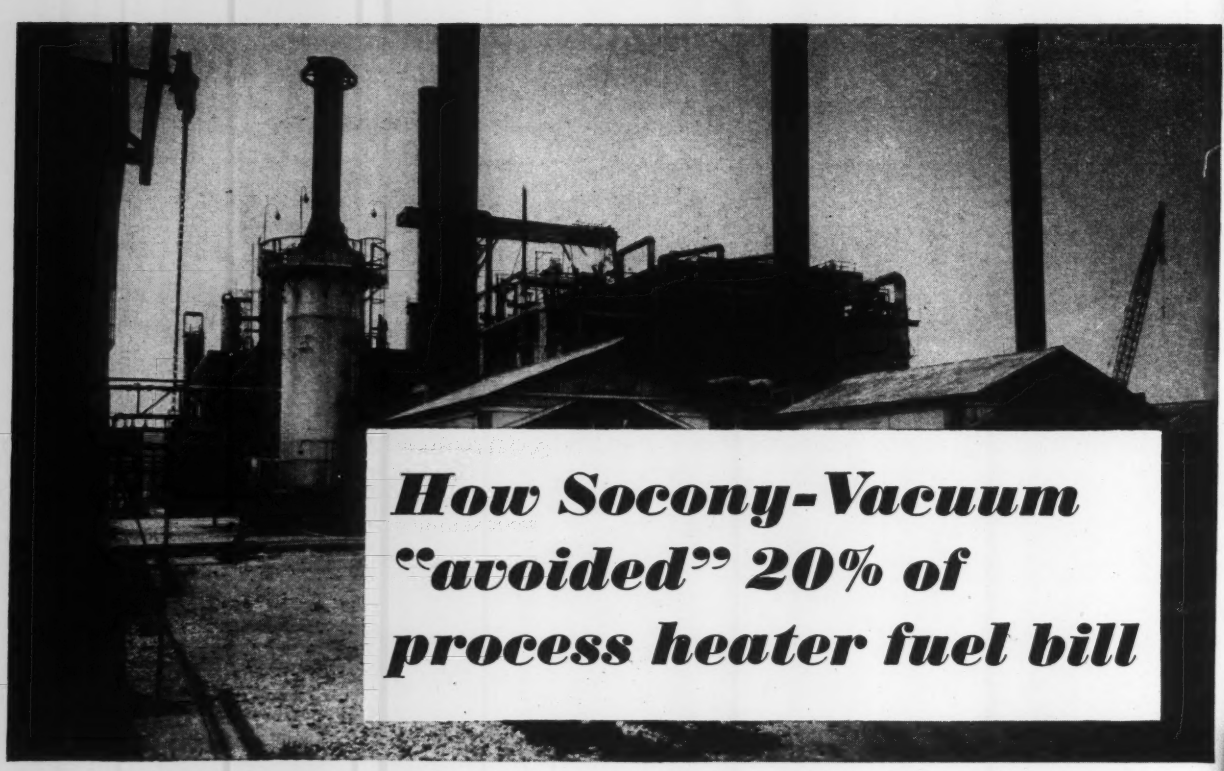
3 **AUTRONIC RECORDER** operates without slide wires or other contacting mechanisms. Electronically controlled pen gives true linear trace. Unit holds 1-month supply of standard 3-inch linear or square root chart paper. Set-point adjustment optional with Autronic Recorder.



4 **AUTRONIC MANUAL CONTROL** makes bumpless changeovers simple. No gauges to synchronize, no readings to remember because indicator shows *difference* between actual and desired output.

Swartwout *Autronic* **CONTROL SYSTEM**

SEND FOR BULLETIN A-701 • THE SWARTWOUT COMPANY • 18511 EUCLID AVENUE • CLEVELAND 12, OHIO



How Socony-Vacuum "avoided" 20% of process heater fuel bill

program

When engineers at Socony-Vacuum, Trenton, Michigan refinery developed a complete fuel conservation program, process heaters came under close scrutiny. Socony-Vacuum engineers felt they could reduce the total cost of fuel used in raising the temperature of petroleum stock if they could keep the amount of excess air in the flue gases at a minimum.

need

Socony's instrument engineers wanted an instrument which would indicate excess air, so that they could make adjustments to keep the air at a minimum and thus save fuel.

specifications for instrument

must provide a **continuous indication** so that changes could be spotted immediately.

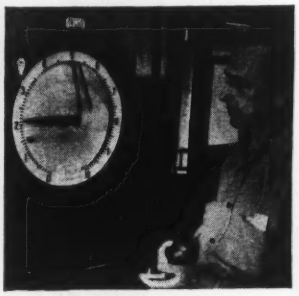
must **not be affected by changes in fuel composition** since different fuels are used in the heater furnaces.

must not **be affected by the presence of Hydrogen** in the gas sample.

preferably, measurement should have **direct relationship to excess air.**

selected

four HAYS MAGNO-THERM OXYGEN ANALYZERS and two HAYS 2-PEN ELECTRONIC RECORDERS



results

The entire fuel conservation program brought a 20% reduction in Socony's annual fuel bill. The Hays Oxygen Recorders have proved an effective combustion guide on the process heaters.

Improvement in the efficiency of your process heaters can mean large fuel savings. Write for Bulletin 50-829, 16 pages of information on how the O_2 meter works, where it's used, etc. No obligation.

THE **HAYS** CORPORATION *MICHIGAN CITY 8, INDIANA*

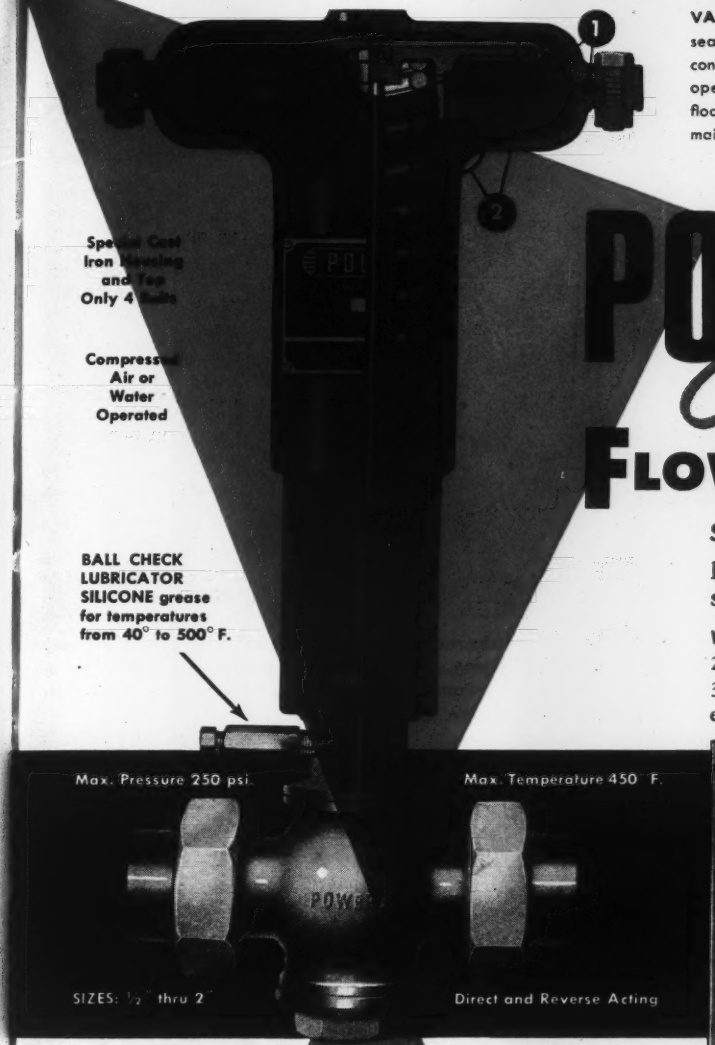
VALVE TOP—Durable moulded neoprene diaphragm (1) has positive sealing bead which provides increased sealing action with increasing control pressure. Efficient diaphragm form insures ample and constant operating power thru full travel. Piston Plate Assembly (2) has a free floating thrust plate which absorbs side thrust. Closely guided piston plate maintains stem in accurate alignment. Maximum air pressure in top, 22 psi.

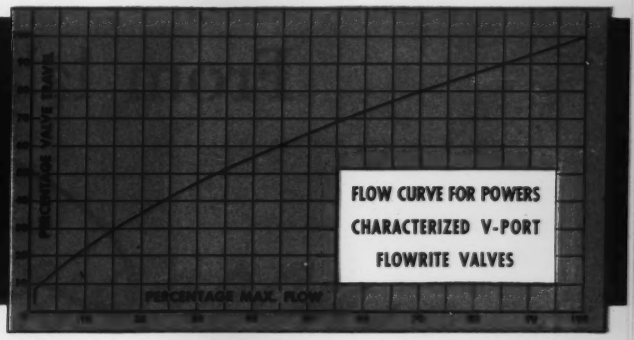
POWERS® SINGLE SEAT V-PORT *Characterized* FLOWRITE VALVES Give—

Special Cast Iron Housing and Top Only 4 Bolts

Compressed Air or Water Operated

BALL CHECK LUBRICATOR SILICONE grease for temperatures from 40° to 500° F.



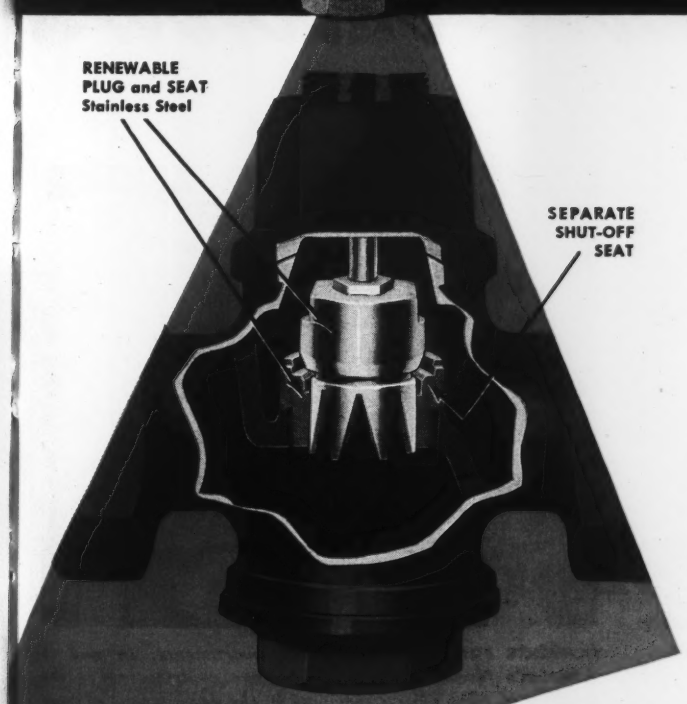


Special Flow Characteristics—High lift V-Port plug provides proportional flow throughout entire lift of stem as shown in chart below.

Wide Variety of Valve Sizes—Nine sizes are available, ½" thru 2". The ½" valve can be furnished with plugs to give 15%, 30%, 60% or 100% of maximum capacity. Plugs are easily interchangeable without removing valve from line.

RENEWABLE PLUG and SEAT Stainless Steel

SEPARATE SHUT-OFF SEAT



Better Control—Less Maintenance—Superior design of stainless steel plug and seat reduces wire drawing, insures longer life and tight shut off. V-Ports do the throttling, protecting separate shut off seat. Plug and seat are truly removable and can be easily replaced in the field. Inner valves are machined and precision ground and lapped within very close tolerances.

Low Hysteresis—Due to smooth rolling diaphragm and polished stainless steel stem in preformed lubricated packing.

Easy to Adjust—Ball bearing adjusting screw; rust proofed steel calibrated springs with full travel in 5 or 10 psi.

Easy to Install—Powers Flowrite V-Port valves have double unions and bronze body with rugged construction to withstand piping strains.

Easy to Service—Valve and top are easy to take apart and re-assemble, facilitating inspection and maintenance.

Reasonably priced. Contact our nearest office for prices and assistance in selecting proper size valves

THE POWERS REGULATOR CO.

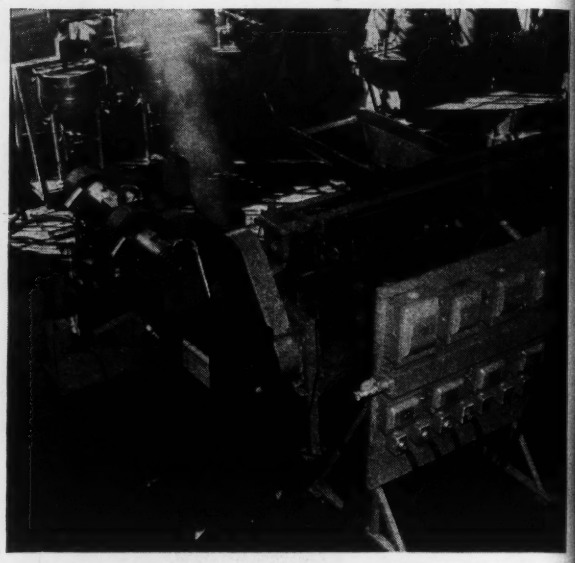
SKOKIE, ILLINOIS • Offices in Over 50 Cities

Chicago 13, Ill., 3819 N. Ashland Ave. • New York 17, N. Y., 231 E. 46th Street
Los Angeles 5, Cal., 1808 West 8th Street • Toronto, Ontario, 195 Spadina Ave.
Mexico, D. F., Apartado 63 Bis. • Honolulu 3, H. I., P. O. 2755—430 Piikoi at Kona

OVER 60 YEARS OF TEMPERATURE AND HUMIDITY CONTROL

(a70)

EFFECTIVE INSULATION—*Used in both research and quality control, these instruments automatically record temperatures at many points in a "test wall" of paper insulating material.*

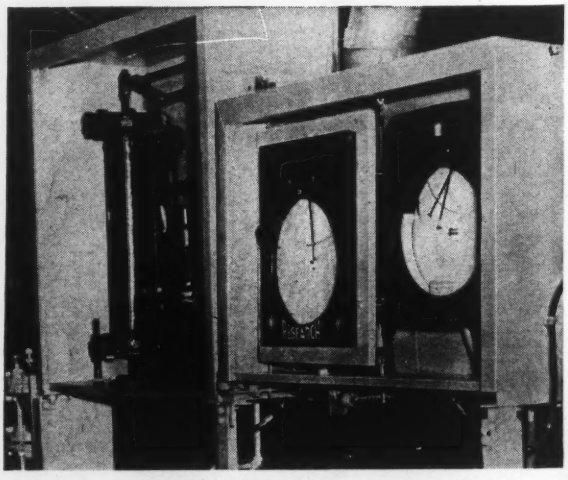


BETTER FOODS MEAN HEALTHIER BABIES—*Pilot plant at Baby Foods Division of Gerber Food Products makes use of* **ElectroniK** *recorder to check all-important processing temperatures during test runs.*

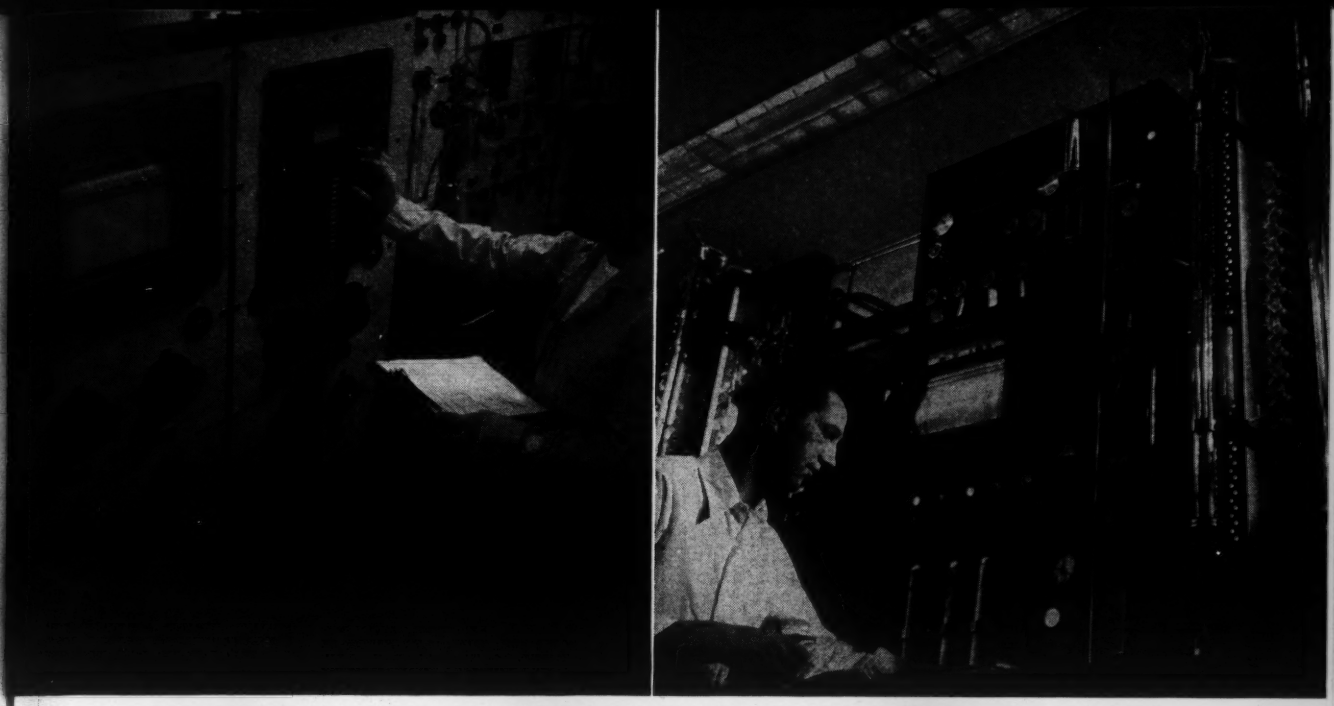
From lab . . . to pilot plant . . . t

Instruments

TORQUE MAGNETOMETER *used by researchers at United States Steel Corporation tells whether a steel sheet can be "drawn" into a deep cap for a ketchup bottle. Shape of curve drawn by recorder pen tells the magnetic, hence the shaping, story.*



FILAMENTS FOR FABRICS — *These instruments, in one of America's foremost rayon plants, are contributing to the stability of pilot plant processing in the development of finer filaments for tomorrow's fabrics.*



RAPID CHEMICAL & TEMPERATURE ANALYSES. *Automatic still (at right) provides accurate record of hydrocarbon concentrations . . . while multi-point ElectroniK Precision Indicator and Recorder provide checks and records of critical temperatures on pilot of new process.*

. to full-scale production

accelerate research

PROVING processes in the pilot plant stage can save untold millions of dollars in "on-stream" operations. But bridging the gap between fluid ounces or pounds in the laboratory and barrels or tons in the plant takes considerable doing.

Thorough instrumentation in the pilot plant provides . . . (1) *a saving in scientific man-hours,* through the centralization of critical data which eliminates the hand logging of hundreds or even thousands of points . . . (2) *easy and rapid interpretation of data,* through automatic coordination and recording in chart form . . . and (3) *process simplification,* through a complete understanding of control problems well in advance of full-scale operations.

Add to these advantages the fact that, with instruments, pilot studies are accomplished in much less time . . . for instruments *accelerate* research. Investigate the wide application possibilities of Brown Instrumentation. Our local engineering representative is qualified to discuss your requirements . . . and he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division,* 4482 Wayne Ave., Philadelphia 44, Pa.

MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls

● *Important Reference Data*

Write for 84-page bulletin "Instruments Accelerate Research" . . . and Data Sheets on instrumentation for a variety of specific applications.

valve after Valve after VALVE-
Processing Industries rely on...

BS&B
Type 86-Climax
DIAPHRAGM CONTROL VALVES

AT WARREN PETROLEUM COMPANY'S big, ultra-modern Gladewater, Texas gasoline plant, Climax valves and controls are standard — as these Type 86R fuel gas regulators.

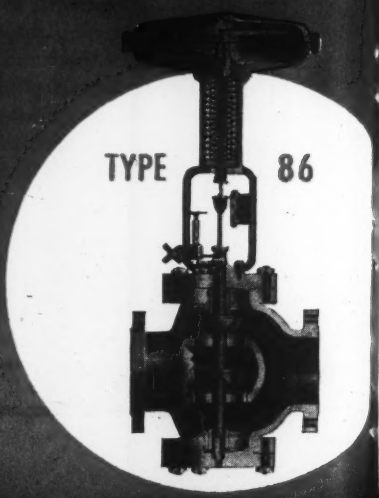
Control of flow, liquid level, pressure and temperature is best achieved by BS&B's Type 86 Climax valves—whether the medium is air, gas, vapor liquid or steam. In any industries where trouble-free performance and ease of maintenance are important—Climax 86 valves have proved their reliability and versatility. BS&B Climax control valves feature wide range, high-lift, true-aligned, reversible inner valves, minimum hysteresis, chattering and shock. Bolted down yokes give added strength so valves can be installed in any position. Face-to-face dimensions of flanges are standard.

A Climax Type 86 is available to you for any control application—with single or double port, reversed topworks, single or double diaphragm, with hand wheels, finned cooling section, purged gland section, bellows stem packing, steam jacketed valve bodies and valve positioners. Pressure ranges are from 125 to 5000 psi; sizes range from ½" to 4" in single port, ½" to 16" in double port valves.

The superiority of Climax valves does not depend alone on their unique design—but on the exacting accuracy of their manufacture, accuracy that demands close tolerances for acceptance by BS&B's Climax Controls Engineers.

CLIMAX CONFIDENTIAL ENGINEERING SERVICE

is available for all your controls problems. You need not hesitate to call on Climax Engineers for assistance—BS&B's reputation for 58 years of customer service stands behind them. Write today for complete illustrated literature on the construction, specifications and application of Climax Diaphragm Control Valves.



CLIMAX BS&B CONTROLS

BLACK, SIVALLS & BRYSON, INC.

CLIMAX CONTROLS DIVISION, DEPT. 411

7500 EAST 12TH STREET KANSAS CITY 3, MISSOURI

SUBJECT INDEX

Instruments The Magazine of MEASUREMENT and CONTROL

Published Monthly by The Instruments Publishing Company
921 Ridge Ave., Pittsburgh 12, Penna.

INDEX TO VOLUME 24, 1951

Issue	Pages	Issue	Pages
January	1-116	July	725-828
February	117-240	August	829-992
March	241-356	September	993-1116
April	357-488	October	1117-1248
May	489-604	November	1249-1376
June	605-724	December	1377-1524

A

Abrasion Tester, Portable 773
Accelerometer, Improved Ramberg Vacuum-tube 196
Accelerometer, Piezoelectric 385
Accelerometer, Recording 302
Accelerometer of Wide Frequency Range, A Ceramic 968
Accelerometers, etc., "G" Standard for Testing 916
Actuators, Limit-switch 1463
Adjustable-case Dial Thermometers 677
Aerial-photography Slide-rule 1066
Air Bleed for Bourdon Tubes 444
Air Cleaner, Centrifugal 561
Air Cylinder, Small 675
Air Pollution Instruments 1057
Air Velocity Controller 64
Aircraft, Stick-force Indicator for 1448
Aircraft Temperature Controller 1459
Air-meter, Portable 548
Alarm, Photoelectric 935
Alpha Survey Meter 75
American Gas Association 717
American Gas Association Issues Instrument Book 1053
American Society of Mechanical Engineers 717
American Society of Tool Engineers 202
American Standard for Electrical Indicating Instruments Revised 355
Ammeters, Recording Voltmeters and 668
Ammonia Plant, Instrumentation of an 158
Amplifier, A-c. or D-c. 1058
Amplifier, Audio 1201
Amplifier, D-c. 310, 1058
Amplifier, Laboratory Carrier 1058
Amplifier, Power 307
Amplifier for Proportional Counting, Linear 189
Amplifier for Recorders, Carrier 60
Amplifier, Servo 681
Amplifier, Servomechanism 304
Amplifier, Ultrahigh-frequency 1446
Amplifier, Ultra-sensitive D-c. 433
Amplifiers, Packaged Magnetic 311
Analog Computer 673, 772
Analysis Unit, Fluorescence 1320
Analysis-unit Charger 1198
Analytical Weights, Box for 1196
Analyzer and Alarm, Gas 1318
Analyzer, Electrical Power 668
Analyzer, Engine 1318
Analyzer, Power 1454
Analyzer, Sound Spectrum 64
Analyzers, Product Quality 1424
Antenna Distribution System 934
Appliance Tester, Sensitizer for 785
Application of Continuous Infrared Analyzers 1296
Application of Dielectric Measurement to Continuous Processes 1434
ASME Symposium on High Pressure 1079
Atomic-energy Plant Hazards, Automatic Control Reduces 200
Atmosphere Generator 1457
Attenuator, Microwave 1074
Attenuators 69
Audio-frequency Standard 672
Automatic Booster Station, Design of an Unattended 884
Automatic Control Conference Held in Bedford, England, July 1951, Some Impressions of the 1172
Automatic Control of Flow in the Process Industries 590
Automatic Control Reduces Atomic-energy Plant Hazards 200
Automatic Gain Compensator Strip 1077
Automatic Pilot for Jet Planes 301
Automatic Reset, "Balanced" and "Variable-linked" 1292
Automatic Sorting Gage 195
Automatic Titrator 193
Automatic Weather Station, Air-launched 1053
Automatically Mixed and Batched, Foundry Sand 1214
Automatize a Paint Company's Product-development Tests, Instruments 1306
Automatized Inspection, Crucial Need of 759
Autopilot, Marine 1317

B

Balance Wheel by Watch-case Reaction, Recording Motion of a Watch 154
"Balanced" and "Variable-linked" Automatic Reset 1292
Ball-bearing Tools 1192
Barrel Filling Meter 180
Base and Socket, Non-interchangeable 69
Battery Tester 1454
Bearing, Nylon 1333
Bellows, Metal 445
Beta Gages 1460
Beta-gamma Survey Meter 75
Boards, Production Control 780
Booster Station, Design of an Unattended Automatic 884
Bore Gage 1319
Borescope, Internal-inspection 676
Bourdon Tubes, Air Bleed for 444
Bridge, The Direct-reading D-c. Strain-gage 400
Bridge, Impedance 1322
Bridge, Megohm 670
Bridge, Universal 1188
Brooklyn-Battery Tunnel, Lighting-Ventilating Control in 296
Bubbler and Sediment Trap, Sight Feed 320
Burette 320
Burette Holder, Double 445

C

CAA Finds "Picture" Instruments Better for Pilots than Symbolic 294
Cabinet, Controlled Temperature and Humidity 930
Calculator, Metal-weight 1205
Calculator for Statistical Analysis 318
Calibrator, Warburg Manometer 441
Camera, Dual-purpose 1452
Camera, Finished-print Recording 62
Camera, Instrumentation 1452
Camera, Research 782
Camera, Synchronous Motion Picture 62
Capacitance Tester 550, 551
Capacitor, High-Q Mica 684
Capacitor, High-voltage 683
Capacitor, Miniature 684
Capacitor Seal 1467
Capacitor, Variable 936
Capacitors, Ceramic 1071
Capacitors in 1500-volt Ratings 438
Capacitors, High-accuracy 1201
Capacitors, Small 793
Carbon Dioxide Indicator, Portable 428
Carbon-determination Apparatus, Induction-heated 61
Carrier Measuring Systems by Time-base Variations in Recording and Reproducing Data, Errors Introduced into F-M 274
Carrier-system Auxiliary 784
Carrier Telephone System 1458
Castings, Radiographic Inspection of Steel 655
Cathode-ray Oscilloscope, Five-inch 308
Cathode-ray Oscilloscope, Miniature 67
Cathode-ray Oscilloscope, Vertical 308
Cathode-ray Tube 679
Cathode-ray Tube, Flying-spot 677
Cathode-ray Tube Reactivator 1460
Cathode-ray Tube, Self-focusing 1326
Cathode-ray Tube, 12-in. 928
Cell, Electronic Standard 437
Ceramic Accelerometer of Wide Frequency Range, A 968
Ceramic Materials 1334
Charger, Analysis-unit 1198
Chassis, Plug-in 1201
Chassis for Plug-in Construction, Basic 1071
Chassis Slides 1205
Chronograph and Chronoscope, Improved Spark 288
Chronoscope and Input Adapter, High-speed 180
Civil Aeronautical Administration Launches Distance Measuring Equipment Program 1178
Clamp, Instrument Mounting 1204
Classifications: Keys to Know-how in Instrument Work 392
Cleaner, Centrifugal Air 561
Cleaner, Small-parts 678
Climate-survey System 1316
Coating, Glare-proof 196
Coatings, High Vacuum Evaporated Optical 284
Cobalt 60, Container for 441
Coil Coated Metal 1326
Collector, Directional Dirt-fall 686
Color Yardstick Measures Microinches 659
Combustible Gas Indicator 182, 184
Comparator, Automatic Resistance 435
Comparator Illuminator 443
Comparator, Internal Thread 559
Comparison of Methods for Measuring Temperature of Molten Metals 766
Components for Instrument Circuits, Quality Electronic 966
Compressed Air for the Instrument Exhibit 1027
Computer, Analog 673, 772
Computer, Differential-analyzer-type Digital 912
Computer, Electrical Analog 778
Computer, Time-study 779
Conductive Coating 320
Conductivity Cells, Armored 317
Conductometer for Electrolytes, Recording 710
Connecting Leads 938
Connection, Voltage Take-off 69
Connector, Tandem-type 1073
Construction and Calibration of a Laboratory Engine Pressure Indicator 156
Container for Cobalt 60 441
Continuous Electronic Recording of the Water Content of Oil Field Emulsions 335
Continuous Measurement of Vapor Pressures of Petroleum Products 468
Contour Mapping of Optical Surfaces with Light Waves 1343
Control, Laundry Washer 686
Control of Liquid Flow, Factors in Precise 705
Control Resistor, Sub-miniature 1466
Control Station, Pendant 685
Control System, Electrical 782
Control System, Electronic 1314
Control System, Electronic Master 61
Control System for Industrial Control Applications, An Electronic 642
Control System, Unitized 1314
Control Valve in Operation, The 1494
Controlled Humidity for Research 1306
Controlled Temperature and Humidity Cabinet 930
Controller, Air Velocity 64
Controller, Air-fuel Ratio 778
Controller, Die Temperature 434
Controller, Electronic Proportioning Input 62
Controller, Explosion-proof Pyrometer 779
Controller, Force-balance Pneumatic 60
Controller, Locked 675
Controller, Process 1314
Controller, Proportional Step-by-step 1315
Controller, Web-material 1314
Controllers, Pyrometer 556
Controllers Speed Tests of Engine Fuels and Lubricants, Indicating 896
Controls, Power Plant 38
Converter, Linear to Logarithmic 433
Cooling Device, Spot 63
Correcting Orifice-meter Measurements for Flow Pulsations, A Method for 763, 1094
Correction Factors for the Balancing Effect of a Gas in One Leg of a Manometer 528
Counter, Automatic Batch 556
Counter Decades 1326
Counter, Driveless 1335
Counter, Electronic 914
Counter, End Window 1460
Counter, Event 557
Counter, Frequency 1324
Counter, Geiger 787
Counter, High-speed 1058
Counter, Industrial Electronic 1210
Counter, Predetermined 62
Counter, Scintillation 439, 1460
Counter, Small Electric 194
Counter, Step-motor 1457
Counters, Automatic Batch 1318
Counters, Electric 445
Counters for High-temperature Work, Geiger-Mueller 1067
Course for Mechanical Engineers, Instrumentation and Automatic Control 406
Crack Detector 782
Crucial Need of Automatized Inspection 759
Crystal Growing Equipment, Process Instrumentation For 585
Crystal Unit, Dual 678
Cylinder, Small Air 675

D

D-c. Supply, High-precision 1060
Dechema 1310
Decontaminating Solution 1461
Degasser, Automatic 778
Dehydrator, Compressed-air 77
Dehydrator for Instrument Air, Filter and 1057
Delay Line 1073
Demineralizer 1194
Demonstration Instruments for Nuclear Processes 1068
Density Indicator, Liquid 300
Derivative-integral Filter 1189
Desiccator 1196
Desiccator Holder 1464
Desk, Magnetic Testing 1324
Detector, Charger & Reader, Minature High-range Radiation 191
Developments in Electronic Instrumentation Including Process Control, Some 42
Dial for Temperature Regulators, Calibrated 448
Die Temperature Controller 434
Dielectric Measurement to Continuous Processes, Application of 1434
Differential-analyzer-type Digital Computer 912
Differential Bridge, Thermometer 1452
Diffraction Gratings, Original 1464
Diode, Germanium Crystal 793
Direct-reading Chart for Beam Scales 430
Direct-reading D-c. Strain-gage Bridge, The 400, 535
Dirt-fall Collector, Directional 686
Displacement Indicator and Controller 781
Distance Measuring Equipment Familiarization Program 1178
Distillation Apparatus, Automatic 674
Dosimeter Charger 1199
Dosimeter with Electrostatic Charger, Low-range Radiation 192
Dosimeter, Photographic-film 1308
Drill, 3-in-1 790
Ductility Testing Machine 73
DUN'S REVIEW 641
Duplicating Attachment, Milling Machine 428
Duplication of Effort Still Rates "Crime" Tag 1027
Dust Collector, Filterless 685
Dust Eliminator, Shop 935
Dust, Microscopic Method for Detecting Silica in 694
Dust, Photoelectric Measurement of 534
Dynamometer 1456
Dynamometer, Magnetic-coupling 183

E

Edge-lighted Instrument Panels 1069
Electrical Instruments, Full-view Switchboard 65
Electrical Measurement, Standards for 35
Electrical Micrometer 1065
Electric-circuit Printers 898
Electrometer 1062
Electrometer, Dynamic Condenser 185
Electrometer, Vacuum-tube 187
Electronic Timers 1439
Electronics (Editorial) 641
Electrophoresis Apparatus 1187
End Measuring Rods 72
Engine Analyzer 1318
Engine Pressure Indicator, Construction and Calibration of a Laboratory 156
Engineering Schools, Survey of Industrial Instruments Courses in 886
Engraver 789
Errors Introduced into F-M Carrier Measuring Systems by Time-base Variations in Recording and Reproducing Data 274
Europe's Industrial and Instrument Fairs, My Second Report to INSTRUMENTS' Readers on 1043
Evaporator, High-vacuum 931
Exposition of Power and Mechanical Engineering, 1950 National 45
Exposure Controller 1458
Exposure Meter 1457

F

Factors in Precise Control of Liquid Flow 705
Fault Locator 1458
Field-intensity Meter, Noise and 1060
Film, Instrumentation 1090
Filter and Dehydrator for Instrument Air 1057
Filter, Derivative-integral 1189
Filter, Half-octave 435
Filter, Low-frequency 1191
Filters, Air-gas 562
Filters, Infra-red-pass 77
Flame Failure Safeguard 929
Flashlight-Magnifier 680
Flaw Detector, Ultrasonic 779
Flow Calculations, Gas Pipeline 345
Flow Control Elements 443
Flow, Factors in Precise Control of Liquid 705
Flow of Fluids through Orifice Meters with Particular Reference to the Measurements of Liquids and Steam, Measurement of 817, 975, 1101
Flow Interlock 439
Flow Measurement, A Non-mathematical Discussion of 470
Flow Meter, A Method for Measuring Pulsating Flow, The Mass 331
Flow in the Process Industries, Automatic Control of 590
Flow Pulsations, A Method for Correcting Orifice-meter Measurements for 763, 1094
Flow Signal Transmitter 668
Flow Transmitter, Pneumatic 60, 548
Flow-control Elements, Time-delay 682
Flowmeter, Aircraft Fuel 301
Flowmeter, Electronic Manometer and 1316
Flowmeter, Induction-type 1184
Flowmeter, Linear-scale 912
Fluorescence Analysis Unit 1320
FM Communications Monitor 188
FM Modulation Meter 1460
Force Indicator, Remote 1057
Foundry Sand Automatically Mixed and Batched 1214
Fractionator, Adsorption 779
Freight, Research Instrumentation as Applied to the Transportation of Perishable 811
Frequency Converter Accessory 432
Frequency Meter, Stroboscopic 67
Frequency Monitor, AM 554
Fuels and Lubricants, Indicating Controllers Speed Tests of Engine 896
Function of the Engineering Publication, The 521
Fuse Extractor Post, Miniature 1204
Fuseholder, Indicator 680
Future of Graphic Panel in Process Control 405

G

"G" Standard for Testing Accelerometers etc. 916

Gage, Automatic Sorting 195
Gage Blocks 426
Gage, Bore 1319
Gage, Dial Groove 441
Gage, Electronic 1452
Gage, Glass Tubing 442
Gage and Jack, Load 923
Gage, Optical Cam Rise 1320
Gage, Pneumatic Dimension 180
Gage, Tin Plating Thickness 72
Gage, Universal Depth 1320
Gaging & Classifying Instrument, Automatic 72
Gaging Head, Electronic 1319
Gaging, Non-contact 652
Gallons Content Nomograph 932
Galvanometer 1466
Galvanometer Shunt, Automatic 307
Galvanometer, Super-sensitive 64
Gamma Tube 1461
Gas Analyzer and Alarm 1318
Gas Analyzer, Recording and Controlling Infrared 912
Gas Indicator, Combustible 182, 184
Gas Measurement Committee Report 717
Gas Pipeline Flow Calculations 345
Gaskets for Water-level Gages 77
Gaussmeter 787
Geiger Counter, Portable 74
Gel-time Meter 1464
Generator and Pickup, AF 306
Generator, Pulse 1456
Generator, Square-wave 928
Generator, Ultrasonic 671, 786
German Hanover Fair, Measuring Instruments and Controllers at the 1170
Germanium Crystal Diode 793
Glare-proof Coating 196
Glass Valves for Vacuum Control 656
Glassware Service, Laboratory 79
G-M Counter, Prospector's 1198
Gordon Research Conferences, AAAS 773
Governor, Overspeed 78
Graphic Panel in Process Control, Future of 405
Grid-dip Meter 1191

H

Hardness Tester 780, 1063
Hardness Tester, Dry 559
Hardness Tester, Micro- 559
Heater 918
Heater for Opening Instrument Cases 194
Heating Cable 1464
Height Indicator 1192
High Vacuum Evaporated Optical Coatings 284
High-pressure Differential Manometer, A 159
High-pressure Drops Through Orifices 279
High-speed Direct-trace Recording Methods 30
Hot-plate, Laboratory 1194, 1322
Housing, Electrical Network 69
Human Factor in Instrument Design, The 1290
Humidity Indicator 687
Himidity, It Isn't the Heat—It's the 280
Humidity for Research, Controlled 1306
Hydraulic Components and Systems, Tester for 921
Hydraulic Press 1473
Hydraulic Remote Control 782
Hydraulic Servocontrols in the Steel Industry 650
Hydraulic-pneumatic Servo System 1462
Hydrogen-Ion, See pH.
Hydrostatic Pressure Generator 560
Hygrometer, Electrical 60

I

Illumination Controller 779
Illuminator, Comparator 443
Illuminometer, Daylight 1316
Indicator for Resistance Thermometers 434
Indicator, three-position 916
Indicators and Control Units, Miniature 773
Induction-motor Rotor Temperatures, Measurement of 410
Industrial Applications of Manometers 231
Industrial Control Applications, An Electronic Control System for 643
Industrial Instruments Courses in Engineering Schools, Survey of 886
Infrared Analyzers, Application of Continuous 1296
Infrared Polarizer 77
Infrared-pass Filters 77
Inputuner, Detent-action Continuous 306
Inspection Borescope, Internal 676
Inspection, Crucial Need of Automatized 759
Inspection Laboratory 1320
Inspection of Steel Castings Radiographic 655
Inspection Unit, Mobile 1463
Inspector and Segregator for Tappets, Automatic 922
Instrument Circuits, Quality Electronic Components for 966
Instrument and Control Maintenance In A Steel Mill 212
Instrument Design, The Human Factor in 1290
Instrument Electronics 760, 888, 1048, 1174, 1300, 1442
Instrument Work, Classifications: Keys to Know-How in 393
Instrumentation of an Ammonia Plant 158
Instrumentation and Automatic Control Course for Mechanical Engineers 406
Instrumentation Film 1090
Instrumentation Minimizes the Welding Variable 1034
Instrumentation in the Petroleum Refining Industry 1168
Instrumentation, Safety 575
Instrumentation, Tunnel 1180
Instrumentology and Instrumentation 153
Instruments, Full-view Switchboard Electrical 65
Insulation Material, Electrical 1332
Insulation Tester 1192, 1456
Insulation Tester, Winding- 1324
Integrator, Ball and Disk 789
Intervalometer 915
Ionization Chamber, Explosion-proof 73
ISA's Sixth Annual Exhibit, Descriptive List 902
Isolation Box 1075
It Isn't the Heat—It's the Humidity 280

J

Join Forces to Develop New Industrial X-ray Process 1308
Journal of the Instrument Society of America 91, 209, 327, 461, 583, 703, 805, 963, 1097, 1221, 1349, 1493
Journal of the Southern California Meter Association 105, 229, 345, 597, 717, 817, 975, 1101, 1235, 1361, 1507

K

"Knows All Angles" 1178

L

Label Tape 936
Labels for Marking Fluid Lines 318
Laboratory Glassware Service 79
Laboratory, Inspection 1320
Lamp Annunciators 1326
Lamp, Utility 1471
Laundry Washer Control 686
L-bank Noise Source 672
Leads, Shielded 1467
Leak Detector 426
Leak Locator, Vacuum 1322
Lens 1320
Level Gage, Frost-proof 553
Light, High-intensity 1471
Light, Low-voltage Test 317
Light, Miniature Indicator 792
Light Waves, Contour Mapping of Optical Surfaces with 1343
Lighting-Ventilating Control in Brooklyn-Battery Tunnel 296
Lights, Neon Pilot 938
Line Pad 1074
Linear to Logarithmic Converter 433
Liquid Dispenser 1472
Liquid-level Transmitter 302
Load Cell, Torsion Bar 1462
Load Cells 316
Load Cells, Tensional 567
Load Gage and Jack 923
Locating Underground Pipes 105
Locomotive-tachometer Test Equipment 305

M

Magnetic Comparator Separates Bolts 1448
Magnetic Head, Miniature 1462
Magnetic Memory 555
Magnetic Observatory in Operation in U. S., Third 200
Magnetic Permeameter 696
Magnetic Recording Rubber 1184
Magnetic Testing Desk 1324
Magnetic Transmission 61
Magnetic-tape Pickup 679
Magnifier, Flashlight- 680
Magnifier, Thermometer 1463
Maintenance In A Steel Mill, Instrument and Control 212
Manometer, Absolute and Differential 668
Manometer Calibrator, Warburg 441
Manometer, Correction Factors for the Balancing Effect of a Gas in One Leg of a 528
Manometer, Flexible 1058
Manometer and Flowmeter, Electronic 1316
Manometer, A High-pressure Differential 159
Manometers, Industrial Applications of 231
Markers, CRO Time 1071
Mass Flow Meter A Method for Measuring Pulsating Flow, The 331
Mass Spectrometer, Analytical 60
Mass Spectrometer for Monitoring Continuous Processes, A 221
Mass, Standards of 530
Master Control System, Electronic 61
M & C Handbook to U. S. and Canada Only 1027
Measurement and Control in the Utilization of Mixed Fuels and Oxygen in Open-hearth Furnaces 1028
Measurement of Flow of Fluids through Orifice Meters with Particular Reference to the Measurements of Liquids and Steam 817, 975, 1101
Measurement of Induction-motor Rotor Temperatures 410
Measuring and Proportioning Method, A Novel 286
Mellon Institute 891
Memory, Magnetic 555
Memory, Static Magnetic 62
Mercury Cleaner 562
Mercury Cleaning Unit, Small 79
Metal Detectors 1062
Metallograph 673
Meter, Barrel Filling 180
Meter, Positive Displacement 314
Methods for Sorting Mixed Metals 522
Micro Hot-hardness Tester, NBS 1342
Microbarograph, Recording 1186
Microinches, Color Yardstick Measures 659
Micrometer, Electrical 1065
Micromicroammeter, D-c. 550
Microphotometer 553
Micropotentiometer, Wide-range R-f. 572
Microscope Base, Tool-maker's 79
Microscope, Metallographic 182
Microscope Slide Field-finder 196
Microscope, Toolroom 1066
Microscopes, Ball-bearing 1320
Microscopes, Laboratory 1194
Microscopes, Toolmaker's 1193
Microscopic Method for Detecting Silica in Dust 694
Microscopy, New Techniques in 772
Microwave Spectrograph—It's Use as an Analytical Instrument, The 1352
Milling Machine Duplicating Attachment 428
Millivoltmeter, Indicating 554
Millivoltmeter, VT 1190
Mine-car Carrier-current Communications System 786
Miniature Transmitter 896
Modification of Portable Strain Indicator for Use with a Closed External Bridge Circuit 533
Moisture Content, Automatic Inspection for 1058
Moisture Meter 780, 1187
Moisture Meter, Grain 933
Moisture Meter, Wood-waste 933
Moisture Tester 548
Moisture Testers, Portable 433
Molten Metals, Comparison of Methods for Measuring Temperature of 766
Molten-metal Temperature Measurement, A Thermocouple System for 769
Moment-balance Scale 1196
Monitor, Line-noise 440
Monitoring Continuous Processes, A Mass Spectrometer for 221
Monochromator, Grating 552
Monochromator, Quartz 193
Motion Picture Camera, Synchronous 62
Motor, Controlled 925
Motor, Small Synchronous 1328
Motor Speed Controller, 1/3-hp. 1060
Motor, Timing 1073
Motors, Miniature D-c. 306
Mounting Clamp, Instrument 1204
Mountings, Antivibration 1070
Mounts, Shock 678
Multi-channel Photographic Recorder 300
Multimeter, Portable 552
Multiple-Unit Signal, Back-lighted 68
Multi-range Indicator, Portable 188
My Second Report to INSTRUMENTS' Readers on Europe's Industrial and Instrument Fairs 1043

N

Networks, Input and Output 1200
New Instruments—8719, 203, 273
New Managing Editor 391
Noise and Field-intensity Meter, 1060, 1191
Noise Meter, Miniature 1062
Noise Monitor, Line- 440
Noise Problem at Regulator Stations, The 1361
Noise Source, L-Band 672
Non-Contact Gaging 652
Non-mathematical Discussion of Flow Measurement, A 470
Nomograph, Gallons Content 932
Novel Measuring and Proportioning Method, A 286
Nuclear Field, Process Instrumentation in The 1295
Nuclear Processes, Demonstration Instruments for 1068

O

Occupational Field, An 641
Oil-burner Controller 1186
Oil-burner Flame Failure Control 300
Oil-line Products Tracked by Radioactivity Recorders 896
"One of the Great Technical Events of the World" 1159
One-knob Production Control 215
Open Letter to Charles Wilson, An 1289
Open Letter to Production Men, An 1289
Open-hearth Furnaces, Measurement and Control in the Utilization of Mixed Fuels and Oxygen in 1028
Operation of a Telemetering System Which Does Not Use Commercial Power at Transmitter 597
Operators for Throttling Control, Pneumatic 1430
Optical Cam Rise Gage 1320
Optical Gaging Projector 426
Optical Rangefinder 426
Ortical Straightedge 926
Orientation Unit, Quartz 1321
Orifice-meter Measurements for Flow Pulsations, A Method for Correcting 763, 1094
Orifices, High-pressure Drops Through 279
Oscillator, Audio 1452
Oscillator, Bridge 304
Oscillator, Bridge-stabilized 304
Oscillator, Low-frequency 434, 1190, 1323
Oscillator with Markers, F-m. 550
Oscillator, Sweeping 304
Oscillator, Wide-range Test 435
Oscillograph, High-speed 668
Oscillograph, 9-channel 1322
Oscilloscope 783, 784
Oscilloscope, Calibrator 308
Oscilloscope Camera 62
Oscilloscope, Dual-channel 1188
Oscilloscope, Portable 927
Oven, Laboratory 674, 1194
Oven, Laboratory Core-baking 193
Oven, Thermostated 931
Overload Warning Signal 317

P

Packaging, Rubberized-fibre Protective 563
Paint, Thermoscopic 930
Panel Board Design, Symposium on 594
Panel Design 1425
Panel Instrument 1184
Panels, Edge-lighted Instrument 1069
Panoramic Indicator 927
Particle Detector-Amplifier 677
Performance Analysis of Butterfly Valves 880
Permeameter 302
Permeameter, Magnetic 696
Petroleum Refining Industry, Instrumentation in the 1168
pH Meter 1188
pH Recorder 1452
pH Standards, New 1212
pH Tester, Portable 550
Phosphors, Crystalline and Plastic 191
Photoelectric Measurement of Dust 534
Photographic-film Dosimeter 1308
Photometer 553, 673
Physical Society Exhibition, Britain's 81
Pickup, Magnetic-tape 679
Pictorial—Houston Exhibit 1160
Pigment for Clinical Thermometers, Durable 1306
Pilot Light 684
Pipe-line Pressure Measurement 896
Pipette Control, Remote 314, 1466
Pitch & Yaw Angles and Pitot & Static Pressures, Pickups for 1057
Pitot & Static Pressures, Pickups for Pitch & Yaw Angles and 1057
Pittsburgh Diffraction Conference 972
Pittsburgh's Temple of Research 891
Planetarium Projector 780
Plug and Receptacle, Three-circuit 1073
Plug-in Chassis 1201
Plug-in Construction, Basic Chassis for 1071
Pneumatic Cylinders 448
Pneumatic Operators for Throttling Control 1430
Pneumatic Servomechanisms in the Iron and Steel Industry 647
Pocket Tool, Instrument Man's 934
Polariscope, High-intensity Color 63
Polarizer, Infrared 77
Polarographic Analysis, Calibrating Unit for 304
Polarographic Instrument, Manual 912
Potential Divider, Precision 307, 436
Potential Importance of Ultrasonic Energy to Industrial Processes 1422
Potentiometer, Sensitive 1452
Power Analyzer, Electrical 668
Power Positioner for Catalyst Slide Valves 1068
Power Supplies, High-voltage 1190
Power Supplies, Metal-enclosed D-c. 188
Power Supply 1323
Power and Mechanical Engineering, 1950 National Exposition of 45
Power Plant Controls 38
Power Supply and Bridge Control, D-C 65
Power Supply, D-c. 187
Power Supply, Klystron 927
Power Supply, Regulated 65, 786, 929, 1323, 1458
Power Supply, Two-circuit 65
Power Supply, Voltage-regulated 566
Power Unit, Pneumatic and Hydraulic 925
Power Unit with Quick-disconnect Fitting, Aircraft 926
Power-factor Tester, Hook-on 671
Press Brake Features Photoelectric Control of Ram Motion 1053
Press, Hydraulic 1321
Press, Laboratory 1196
Pressure Cell, SR-4 Differential 300
Pressure Cells 566
Pressure Generator, Hydrostatic 560
Pressure Indicator, Peak- 780
Pressure Reducer, High- 1462
Pressure Transmitter 1318
Pressure-measuring System, Dynamic 1063
Printer, Electric 781
Printers, Electric-circuit 898
Process Control, Some Developments in Electronic Instrumentation Including 42
Process Instrumentation For Crystal Growing Equipment 585
Process Instrumentation in The Nuclear Field 1295
Processes, A Mass Spectrometer for Monitoring Continuous 221
Product-development Tests, Instruments Automatize a Paint Company's 1306
Product Quality Analyzers 1424
Production Control Boards 780
Production Control, One-knob 215
Production Processes, Remote Supervision of Industrial 402
Projector 925
Projector, Optical Gaging 426
Projector, Planetarium 780
Proportioning Input Controller, Electronic 62
Publication, The Function of the Engineering 521
Pulsating Flow, The Mass Flow Meter A Method for Measuring 331
Pulsations, A Method for Correcting Orifice-meter Measurements for Flow 763, 1094
Pulse Generator 305, 1324
Pulse Generator, Calibrating 302
Pulse Generator and Calibrator 1188
Pump, Positive-displacement 318
Pumps, Metering 1334
Purge Meter 1333
Pyrometer Controller, Explosion-proof 779
Pyrometer Controllers 556
Pyrometer, Immersion Thermocouple 778
Pyrometer, Portable 778
Pyrometer Supplies 791
Pyrometers Control New High-gradient Heating Process, Radiation 878
Pyrometers, Millivoltmeter 180

Q

Quartz Orientation Unit 1321
Quality Analyzers, Product 1424

Question and Answer Session at Texas A & M's Fifth Annual Symposium 160

R

Radiation Absorber Changer 1199
Radiation Dosimeter 923
Radiation Dosimeters 1067
Radiation Monitor 74, 924, 1460
Radiation Probe 1461
Radiation Pyrometers Control New High-gradient Heating Process 878
Radiation Survey Meter 1067, 1196
Radiation-pyrometer-type Wide-range Thermometer 1184
Radioactivity Counter 557, 676, 788
Radioactivity Detector 677
Radioactivity Detector, Finger Chamber 315
Radioactivity Detector, Pocket Chamber 315
Radioactivity Detector for Workers' Hands and Feet 192
Radioactivity Dosimeter Charger 1199
Radioactivity Recorders, Oil-line Products Tracked by 896
Radioactivity Scaler 440
Radioactivity Scalers 440
Radioactivity Warning Label 687
Radiographic Inspection of Steel Castings 655
Railway Signaling 96
Ram Motion Press Brake Features Photoelectric Control of 1053
Ramberg Vacuum-tube Accelerometer, Improved 198
Rangefinder, Optical 426
Ratemeter, Isotope 924
Ratemeter for X-Radiation 75
Recorder with Adjustable Range and Zero Suppression 302
Recorder, Current 1455
Recorder Drive, Multi-channel Tape 62
Recorder, High-speed 784
Recorder, High-speed Inkless Strain 185
Recorder, Multi-channel Photographic 300
Recorder, Multi-point Strip-chart 426
Recorder, Two-pen 182
Recorder, Two-pen Electronic 426
Recorder, X-Y 548
Recorder-Controller, Air-operated Strip-chart 1056
Recorders, Running-time 915
Recording Conductometer for Electrolytes 710
Recording Methods, High-speed Direct-trace 30
Recording Motion of a Watch Balance Wheel by Watch-case Reaction 154
Rectifier Cartridge, High-voltage Selenium 191
Rectifier, Subminiature Selenium 312
Rectifier, Xenon-filled 1325
Rectifiers, 1.2-kw. 1072
Rectifiers, Sealed Selenium 1202
Reflections at the End of a Year 1421
Refractometer, Honey 567
Regulator, Electrical Automatic 783
Regulator, Line-voltage 1458
Regulator, Reverse-action 1184
Regulator Stations, The Noise Problem at 1361
Regulator, Temperature 668
Regulators, Feeder Voltage 555
Regulators, Three-phase Induction 306
Relay, Adjustable Hermetically-sealed Timing 312
Relay, Alternator 1318
Relay, Delayed-reset Time-delay 1328
Relay, D-c. 940
Relay, High-gain 1201
Relay, Low-capacitance 1077
Relay, Mercury-contact Plunger 679
Relay, Multiple 1202
Relay, Sealed 1469, 1470
Relay, Small 1382
Relay, Subminiature 940
Relay Test Set 918
Relay, Time-delay 564, 1076
Relay, Voltage-sensitive 311
Relays, Electronic 1328
Relays, Miniature D-c. Multiple 310
Relays, Plate Circuit 311
Relays, Sealed 1076
Relays, Subminiature 1075
Remote Control, Hydraulic 782
Remote Control of Mechanisms in Vacuum Chamber 1180
Remote Supervision of Industrial Production Processes 402
Research Instrumentation as Applied to the Transportation of Perishable Freight 811
Resistance Comparator, Automatic 435
Resistance Thermometer, Electronic 60
Resistor Box, Decade 687
Resistor, Replaceable Power 190
Resistor, Subminiature 1078
Resistor, Voltage Dividing, Subminiature 1202
Resistors 1466
Resistors, Deposited-carbon 1466
Resistors, Miniature 1079
Resistors, Precision 436, 1330
Resistors, Small Power 1330
Resistors with Boron, Deposited Carbon 439
Resistors, Voltage-dividing 938
Resistors, Wire-wound 437
Resistors Wound on Continuous Forms, 360-deg. 938
Response Rate of Primary Temperature-measuring Elements 1446
R-f. Dielectric Standards 1050
R-f. Micropotentiometer, Wide-range 572
R-f. Power-measuring Equipment 785
R-f. Step-up Coils 70
R-f. Test Set 1062
Rheostats, Multiple Pot- 1467
Rheostats, Precision Dual 1078
Rheostats, Vitreous-enamel 1202
Rheostats, Wire-wound 683
Ring Balance Meters 1507
Robots, Electronic 773
Roll-temperature Measuring Element 300
Rotameters 229
Rotor Temperature Recorder 180
Rubber, Magnetic Recording 1184
Rubberized-fibre Protective Packaging 563
Running-time Meter 779

S

Safety Award for Instrument Department 1504
Safety Instrumentation 575
Sampling Monitor for Production-quality Control 779
Sand Press 1472
Scale, Moment-balance 1196
Scaler, Binary 788
Scaler, Scintillation 787
Scales, Direct-reading Chart for Beam 430
Scintillation Counter 439
Scintillation Counter Operates in One Billionth of a Second 773
Scintillation Detector 1199
Scintillation Scaler 787
Selenium Rectifiers, Molded-in 1467
"Selling" You to Top Executives 1027
Servo Amplifiers 1459
Servo Kit 1326
Servoamplifier 681
Servocontrols in the Steel Industry, Hydraulic 650
Servomechanisms in the Iron and Steel Industry, Pneumatic 647
Servomotors 1325
Shadowing Unit for Electron Microscopes 1057
Sheet Metal Tester 1193
Shock Mounts 678
Shunt, Automatic Galvanometer 307
Shuttle Tension Tester 442
Sight Feed Bubbler and Sediment Trap 320
Signal, Back-lighted Multiple-Unit 68
Signal Flasher 1336
Signal Generator, Microvolt 189
Signal Generator, Super-high-frequency 66
Signal, Overload Warning 317
Signaling, Railway 96
Silica in Dust, Microscopic Method for Detecting 694
Simplified Thermocouple for Temperature Measurements in High Velocity Gas Streams, A 338
Single-sweep Accessory 1325
Slide-rule, Aerial-photography 1066
Smoke Density Recorder 1317
Smoke Detector for Aircraft 426
Society for Applied Spectroscopy 81, 202 972, 1079
Soil-resistivity Meter 1455
Solder Flux, Aluminum 315
Solder, High-temperature Soft 567
Solder-pot, Instrument-shop 934
Solder, Resin Core 1470
Solenoid 684
Solonoid Contactor 1075
Solenoid Housing, Explosion-proof 563
Some Impressions of the Automatic Control Conference Held in Bedford, England, July 1951 1172
Sorting Mixed Metals, Methods for 522
Sound Spectrum Analyzer 64
Spark Chronograph and Chronoscope, Improved 288
Spectrograph—Its Use as an Analytical Instrument, The Microwave 1352
Spectrometer, Analytical Mass 60
Spectrometer, Direct-reading 426
Spectrometer, Infrared 1056
Spectrometer, Mobile Infrared 184
Spectrophotometer, Infrared 1057
Speed Drive, Variable- 1070
Speed Indicator, Stroboscopic 561
Speedometer-odometer for Farm Tractors 932
Spotweld Control 780
Stabilizer, Current 1461
Standard, Audio-frequency 672
Standard Cell, Electronic 437
Standard for Electrical Indicating Instruments Revised, American 355
Standardization of I-C Thermocouple Tables 29
Standards for Electrical Measurement 34
Standards of Mass 530
Standards, New pH 1212
Standards, R-f. Dielectric 1050
Starter-controller 780
Starters, Part Winding 791
Static Electricity Eliminator 1336
Static Magnetic Memory 62
Stepmeter Reveals Mechanics of Walking, Electronic 700
Stereoscope, Hand 1335
Stethoscope, Electronic 1454
Stick-force Indicator for Aircraft 1448
Stirrer, Laboratory 442
Stirrer, Magnetic 1069
Storage Cells, High-rate-discharge 1332
Straightedge, Optical 926
Strain Gage 791
Strain Gage, Temperature-compensated 73
Strain Gage, Unbonded Resistance-wire 1200
Strain Indicator for Use with a Closed External Bridge Circuit, Modification of Portable 533
Strain Recorder, High-speed Inkless 185
Strain-gage Bridge, The Direct-reading D-c. 400, 535
Strain-gage Tests, Multiple 698
"Stratosphere" Test Chamber 1178
Stroboscopic Speed Indicator 561
Subminiature Electrical Instrument 1455
Suppressors, Automotive RF Interference 313
Surface Plate, Black-granite 432
Surface Tension Instrument 920
Surge Comparison Tester 1456
Survey Meter, Alpha 75
Survey Meter, Beta-Gamma 75
Sweep Generator 1060
Sweep Marker, Wide-band 184
Sweep-operated Oscilloscope Beam Blanker with Tissue Stimulator Synchronizer 408
Switch Actuators, Limit- 1468
Switch, Actuators, Rotary 1203
Switch, Alternate-contact 1469
Switch Cover, Removable 314
Switch, Level 1187
Switch, Limit 1203
Switch, Mercury Safety 71
Switch, Miniature 1468
Switch, Miniature Rotary 1077
Switch, Pressure-actuated 438
Switch, Rotary Selector 309, 1330
Switches, Attenuator 1203
Switches, Ganged 680
Switches, Lever-actuated 1077
Switches, Magnetic Blow-out 1329
Switches, Rotary 1329
Switches, Rotary Selector 439
Switches, Snap-action 1329
Switching and Mixing Equipment, Video 1204
Symposium on Standardization of Thermocouple Wire Specifications, The First 877
Sync-signal Pickup 563

T

Tablet Disintegration-rate Tester 73
Tachometer, Engine 310
Tachometer, Hand 1070
Tachometer Indicator 671
Tachometer, Multi-point 931
Tachometer, Portable Recording 182
Tachometer, Stroboscopic 303
Tachometer Test Equipment, Locomotive- 305
Tape, Label 936
Tape Recorder Drive, Multi-channel 62
Teaching Aid, A 641
Telemetering Developments 1235
Telemetering System Which Does Not Use Commercial Power at Transmitter, Operation of a 597
Telescope 1335
Television Aids Steel Making 656
Television Bar Generator 1062
Television Transmitter, Wired 66
Temperature Controller 779
Temperature Controller, Electrical-switch Type 1186
Temperature Controller, Non-indicating Pneumatic 1056
Temperature Controller, Pneumatic or Hydraulic 1057
Temperature Indicators, Power Transformer Winding 933
Temperature of Molten Metals, Comparison of Methods for Measuring 766
Temperature-measuring Elements, Response Rate of Primary 1446
Temperature Regulator, Electronic 187
Temperature Regulators, Calibrated Dial for 448
Temperature Scanning System 1314
Terminal, Solderless 1332
Terminals, Molded 190
Test Chamber, High-altitude 316
Test Fixture, Heavy-duty 1331
Test Set, Relay 918
Test Stand, Hot-cold 319
Tester Accessories, Tensile 1321
Tester, Concrete-beam 560
Tester, C-r. Tube 68
Tester, Dry Hardness 559
Tester, High-current 1324
Tester for Hydraulic Components and Systems 921
Tester, Micro-hardness 559
Tester, NBS Micro Hot-hardness 1342
Tester, Portable Hardness 194
Tester, Sheet Metal 1193
Tester, Shuttle Tension 442
Tester, Tablet Disintegration-rate 73
Tester, Winding-insulation 1324
Testing Machine, Ductility 73
Testing Machine, 12,000-lb. 922
Testing Machines 302
Testing Machines, Universal 1064
Test-prod Adaptor 1200
Thermal Noise Source 65
Thermocouple Gage, Multi-station 548
Thermocouple System for Molten-metal Temperature Measurement, A 769
Thermocouple Tables, Standardization of I-C 29
Thermocouple for Temperature Measurements in High Velocity Gas Streams, A Simplified 338
Thermocouple Wire Specifications, The First Symposium on Standardization of 877
Thermometer, Averaging Resistance 430
Thermometer, Cupcase 1056
Thermometer, Differential Bridge 1452
Thermometer, Electronic Resistance 60
Thermometer Elements, Resistance 1466
Thermometer Magnifier 1463
Thermometer, Platinum Resistance 436
Thermometer, Radiation-pyrometer-type Wide-range 1184
Thermometer, Resistance 1454
Thermometer, Steel-case 778
Thermometer, Surface-temperature 1454
Thermometers, Adjustable-case Dial 677
Thermometers, Bimetallic 1317
Thermometers, Durable Pigment for Clinical 1306
Thermometers, Indicator for Resistance 434
Thermoscopic Paints 1335
Thermostat, Bimetal 1463
Thermostat, Snap-action 444
Thermostat, Surface-type 444
Thermowell, Ground-thread 562
Thickness Controller, Wire-coating 195
Thickness Gage, Beta-ray 550
Thickness Gage, Ceramic 692
Thickness Gage, Portable 71
Third Magnetic Observatory in Operation in U. S. 200
Thread Comparator, Internal 559
Thread-gaging Tool 1465
Time-delay Flow-control Elements 682
Time-delay Generator 65, 1189
Time-study Computer 779
Timer and Counter, RF 180
Timer, Hermetically-sealed Electronic 584
Timer, Interval 566, 915
Timer, Microsecond 303
Timer, Multi-cam 565
Timer, Multiple-circuit 564
Timer, Synchronous-motor 565
Timer, Welding 1065
Timers, Electronic 1439
Timers, Interval 1188
Timers, Pneumatic 313
Tissue Stimulator Synchronizer, Sweep-operated Oscilloscope Beam Blanker with 408
Titrator, Automatic 193, 921
Tool, Instrument Man's Pocket 934
Tool-room Measuring Instrument 300
Torch, Compressed-Fuel 1471
Torque-measuring Instrument 71
Torquemeter on Aircraft Test Stand 572
Torsion Bar Load Cell 1462
Transformer, Indoor-outdoor Current 1071
Transformer, Variable 1336, 1469
Transformer Winding Temperature Indicators, Power 933
Transmission Set 1460
Transmission, Magnetic 61
Transmitter, Four-pole Remote Position 60
Transmitter, Miniature 896
Triode, High-power 567
Triode, Oscillator 1073
Triode, UHF Plate-pulsed Power 313
Tube, Cathode-ray 679
Tube, Gas-filled Grid-controlled Rectifier 70
Tube Tester 305
Tunnel Instrumentation 1180
TV Field Strength Indicator 67
TV Transmitter Equipment 1058

U

UHF Sweep-Marker Generator 1459
Ultrahigh-frequency Amplifier 1446
Ultrasonic Energy to Industrial Processes, Potential Importance of 1422
Ultrasonic Generator 671, 786
Unbonded Resistance-wire Strain Gage 1200

V

Vacuum Chamber, Remote Control of Mechanisms in 1180
Vacuum Control, Glass Valves for 656
Vacuum Gage 781, 918
Vacuum Gage, Thermocouple 187, 548
Vacuum Leak Locator 1322
Vacuum Pump, Small 560
Valve Actuators 1184
Valve, Air-line Drain 559
Valve, Combination Automatic Manual-control 446
Valve, Combination Shut-off and Safety 926
Valve, Float 1462
Valve in Operation, The Control 1494
Valve, Manual Control 791
Valve, Off-center Relief 76
Valve, Rubber Lined 446
Valve, Safety Cleanout 1332
Valve, Solenoid 447
Valve, Solenoid Hydraulic 1186
Valve, Stainless-steel 558
Valve, Surge-damping 789
Valve, Water Heater Relief 76
Valve, Weather-controlled Steam 430
Valves, Cylinder Speed-control 196
Valves, Hydraulic Control 316
Valves, Large Double-ported 76
Valves, Multi-assembly Relief 675
Valves, Packless Reducing 558
Valves, Performance Analysis of Butterfly 880
Valves, Power Positioner for Catalyst Slide 1068
Valves, Servo Control 447
Vapor Pressures of Petroleum Products, Continuous Measurement of 468
Variable-speed Drive 1070
Variable-speed Drive, Miniature 443
Velocity-stroke Indicator 1184
Ventilating Control in Brooklyn-Battery Tunnel, Lighting- 296
Vibration Exciter 1186
Vibration Isolators 78, 1205, 1334
Vibration Isolators, Air-damped 195
Vibration Mounts for Wide Ambient Range 78
Vibration and Noise Analyzer 186
Vibration and Strain Analyzer 180
Vibration Mount 1464
Vibration Tester 923, 1064
Video Generator 929
Video Roll-off Network 928
Viscosimeter, Oil-field 1316
Viscosimeter Stand 1465
Viscosity Bath 1465
Voltage Regulators, Feeder 555
Voltage-Dividing Resistor 682, 683
Voltage-dividing Rheostat, Calibrated 190
Voltage-dividing Rheostats, Hermetically-sealed 438
Voltage-dividing Rheostats, Precision 1330
Voltage-dividing Rheostats, Precision Wire-wound 1331
Voltage-dividing Rheostats, Sealed 1331
Voltmeter, Vacuum-tube 309
Voltmeters and Ammeters, Recording 663
Volt-ohmmeter 1189
Volt-ohm-milliammeter 433, 670
Volume Controls 1074
Volume Controls, Sub-miniature 437

W

Walking, Electronic Stepmeter Reveals Mechanics of 700
Washer, Laboratory Glassware 1194
Water Content of Oil Field Emulsions, Continuous Electronic Recording of the 335
Water-level Gages, Gaskets for 77

Wattmeter, A-f. 189
Waveguide Detector Mounts 1072
Waveguide Power Termination 681
Waveguide Test Equipment 303
Waveguide Tuner 681
Weather Station, Air-launched Automatic 1053
Weather-controlled Steam Valve 430
Weather-forecasting Techniques with G-E Analytical Mass Spectrometer 294
Web-material Controller 1314
Weighing Systems, Electrical 1056
Weight Indicator, Industrial 319
Weight Transmitter, Pneumatic 1316
Welding Variable, Instrumentation Minimizes the 1034
"What Is in a Name?" 153
Wind Velocity Recorder 920

X

X-ray Crystal Detector 300
X-ray Film Viewer 1470
X-ray Process, Join Forces to Develop New Industrial 1308
X-Y Recorder 548

Y

Your Trip to Houston (Editorial) 759

BOOKS

A.S.M.E. MECHANICAL CATALOG AND DIRECTORY 324
BASIC ELECTRICAL MEASUREMENTS 687
CHEMICAL ENGINEERING CATALOG 324
ELECTROMECHANICAL TRANSDUCERS AND WAVE FILTERS 1346
ELECTRONIC ENGINEERING MASTER INDEX 1949 324
ENCYCLOPEDIA ON CATHODE-RAY OSCILLOSCOPES AND THEIR USES 687
HANDBOOK OF POWER RESISTORS 1477
INFRARED RADIATION THERAPY SOURCES AND THEIR ANALYSIS WITH SCANNER 687
INTRODUCTION TO THE THEORY OF CONTROL IN MECHANICAL ENGINEERING 1346
INTRODUCTORY QUANTITATIVE ANALYSIS 687
MODERN INTERFEROMETERS 1476
PHYSICS IN CHEMICAL INDUSTRY 324
RECEIVER CIRCUITRY AND OPERATION 1477
SCMA HANDBOOK 1477
SERVOMECHANISMS AND REGULATING SYSTEM DESIGN (Vol. 1) 1477
SYNTHESIS OF ELECTRONIC COMPUTING AND CONTROL CIRCUITS 1476
TECHNICAL OPTICS 324
VACUUM-TUBE VOLTMETERS (2nd Ed.) 1346
VIBRATION AND SHOCK ISOLATION 1476

AUTHOR INDEX

A

Abbeon Supply Company 680
Adeszko, C. F. 215
Aero Electronics Company 1184
Aerovox Corporation 684
Aget-Detroit Company 685
Ainsworth & Sons, Inc., William 1196
Air Force Cambridge Research Laboratory 294
Aircraft-Marine Products, Inc. 1332
AiResearch Mfg. Co. 187
Alden Products Co. 62, 69, 555, 680, 792, 1071
Allen-Bradley Company 685, 686, 791
Allied Control Co., Inc. 1075
Allis-Chalmers Mfg. Co. 783, 1328
All-State Welding Alloys Co., Inc. 315
American Chronoscope Corp. 180
American Gas Association 1053
American Instrument Co. 553, 560
American Paulin System 1186
American Standards Association 335
American Time Products, Inc. 672
Ames Precision Machine Works 194
Amperex Electronic Corp. 567
Analytical Measurements, Inc. 550
Andrew Technical Service 687
Anetsberger Bros., Inc. 930
Annin Valve Company 446
Anco Instrument Div. 1454
Applied Physics Laboratory of the Johns Hopkins University 896
Applied Research Laboratories 426
Aronson, M. H. 760, 888, 1048, 1159, 1174, 1300, 1421, 1442
Ashman, L. E. 710
Assembly Products, Inc. 434, 556, 779, 1201
Associated Engineering Corp. of Boston 938
Associated Research, Inc. 1192, 1455
Association of American Railroads 811
Atlas Valve Co. 76
Atomlab, Inc. 1461, 1466
Atomic Instrument Company 676, 788
Audio Instrument Co. 307, 433
Austin Co. 192
Automatic Temperature Control Co. 62, 1314, 1318, 1326, 1462
Avion Instrument Corp. 182

B

Bailey Meter Company 778
Baird Associates Inc. 552, 912
Baker Company 1192
Baldwin-Lima-Hamilton Corp. (formerly Baldwin Locomotive Works) 71, 73, 185, 300, 316, 548, 566, 567, 572, 791, 896, 922, 1214
Barber-Colman Co. 1459
Barksdale Valves 316
Barry Corp. 78, 195, 1070, 1205, 1334
Battelle Memorial Institute 1308
Baughman, G. W. 96
Bausch & Lomb Optical Co. 567, 694, 1194, 1320, 1335
Beals, Jr., Lynn S. 1290
Bean, Howard S. 528
Beckett, W. J. 229
Beckman Instruments, Inc. 193
Beckman & Whitley, Inc. 1316
Beede, H. M. 338
Behar, M. F. 153, 393, 759, 877, 891, 1027
Bell, Kenneth A. 886
Bellows Company 675
Bennett, A. L. 408
Berkeley Scientific Corp. 440, 914
Berkshire Laboratories 69, 793, 1071
Berry, Clifford E. 221
Beseler Company, Charles 924
Bethlehem Apparatus Co. 79, 562, 1196
Biddle Company, James C. 1070
Biles, Martin B. 159
Blodgett, Katharine B. 659
Boeckeler Instrument Company 428
Boeing Airplane Company 698
Bolsey Corp. of America 782
Boonton Radio Corporation 432
Arthur E. Booth Co. 65, 918
Bower, L. C. 1439
Bowman, C. E. 533
Bowser, Inc. 314
Brand, D. 331
Branson Instruments, Inc. 779
Brenner, Abner 1342
Bristol Company 668, 915
Brookfield Engineering Labs., Inc. 1465
Brooks Rotameter Co. 1333
Brown Electro-Measurement Corp. 1322
Brown Fintube Company 918
Brush Development Company 679, 1058, 1184
Buck Engineering Co., Inc. 785
Burling Instrument Co. 1056, 1186
Burrell Corporation 779
Burrows Equipment Company 433
Butterworth, J. W. 1422

C

C. A. Practical Electric Company 684
Cambridge Instrument Co. 1452
Cambridge Thermionic Corp. 193
Candler, C. 1476
Cannon Electric Company 1073
Carner Company, Inc., D. R. 790
Carpenter, C. F. 301
Catheron, Allan B. 705
Cauger, Edward H. 1028
Cherry-Channer Corp. 1329
Chestnut, Harold 1477
Chicago Industrial Instrument Co. 190, 433
Chicago Metal Hose Corp. 445
Cinema Engineering Company 1201, 1466
Civil Aeronautics Administration 1178
Clare & Company, C. P. 940, 1328
Clark, W. R. 966
Clarostat Mfg. Co., Inc. 190, 314, 436, 437, 1074, 1331, 1466, 1467
Clarridge, R. E. 167
Clippard Instrument Laboratory, Inc. 435
Coated Coil Corp. 1336
Coe, Dr. James C. 274
Cohen, R. S. 710
Cohn, Sylva Dushkes 880
Cole Instrument Co. 1330, 1331
Coleman Instruments, Inc. 921
Collins Granite Surface Plate Co. 432
Combustion Control Corp. 929
Computation Laboratory, Harvard University 1476
Computer Corp. of America 673
Computer Research Corp. 1462
Conn Ltd., C. G. 67
Conoflow Corporation 448, 1068, 1430
Consolidated Engineering Corp 60, 1322
Continental Electric Company 781
Conway, Martin J. 1028
Cook Electric Co. 62
Coolidge, John E. 534
Cornell-Dubilier Electric Corp. 314, 684
Cosa Corporation 1063, 1193
Cowan, William L. 817, 975, 1101
Cox, H. W. 878
Craig, W. J. 533
Cramer Co., Inc., R. W. 564, 779
Crede, Charles E. 1476
Cubic Corporation 938
Cuthbert, J. H. 212

D

Dahl, A. I. 1446
Dale Products, Inc. 1330
Daven Co. 69, 189, 309, 439, 928, 1074, 1200, 1329, 1460
Davis, Elwood T. 642
Day Company 935
Dayton Rogers Mfg. Co. 1205
Deakin & Son, J. Arthur 1066, 1193
DeJur-Amsco Corporation 938, 1078, 1330
Demonet, E. A. 1439
Denison Engineering Company 789, 1186
Devtco Corporation 778
Devine, J. M. 1296
Dice Company, J. W. 1065
Dietert Company, Harry W. 559, 1472
Dillon & Co., Inc., W. C. 317, 319, 923, 1057, 1064, 1317
Distillation Products Industries 426, 548
DoALL Company 426, 1463
Dominion Electric Corp. 1194
Doschek, Antony 522
Drake Mfg. Company 938
Droms, C. R. 338
DuMont Laboratories, Inc., Allen B. 62, 66, 306, 679, 1058, 1204, 1326
Duncan & Bayley 1456
Dunn, A. L. 408
Durant Mfg. Company 445
Dwyer Mfg. Company, F. W. 428, 438, 1058
Dyna Labs, Inc. 787

E

Eastman Kodak Company 426, 1452
Eberbach and Son Company 686
Ebert Electronics Company 679
Eckman, Donald P. 1430
Eggleston, Jr., H. 105
Electric Hotpack Company 931
Electro Development Corp. 1077
Electro-Mechanical Instrument Co. 1455
Electro Products Laboratories 306, 1063, 1323
Electro-Mechanical Research, Inc. 928
Electronic Devices, Inc. 1467
Electronic Engineering Associates, Ltd. 1058
Electronic Instrument Co., Inc. 552
Electronic Measurements Co. 303, 1458
Electronic Rectifier Co., Inc. 1072
Electronic Tube Corp. 180, 1188
Electronics, Inc. 772
Electrons, Inc. 70
Empire Devices, Inc. 1191
Engelder, P. O. 335
Engineer Research and Development Labs. 1178
Engineering Research Associates, Inc. 302
Erb & Gray 79
Ercona Corporation 780
Eriez Mfg. Company 1062
Ess Instrument Company 1317
Essex Wire Corporation 1077
Evans, F. C. 402
Exact Weight Scale Company 1196
Exhibit Supply Co. 1468

F

Fairchild Camera and Instrument Corp. 682
Federal Products Corp. 71, 180, 195
Fielden Instrument Corp. 1187, 1315
Finn & Company, Inc., T. R. 678
Flock, E. F. 1446
Fischer and Porter Co. 60
Fisher Scientific Co. 61, 442, 1194, 1322, 1463, 1464
Flanagan, John M. 655
Fleming, Lawrence T. 968
Flight Research Engineering Corp. 62
Fluid Controls Company, Inc. 1316
Ford Instrument Co. 1325
Forman, R. 656
Frazer, Robert E. 284
Frommer, Joseph C. 286

G

Gardner Laboratory, Inc. 932
General Cement Mfg. Co. 320
General Controls Company 565, 914, 926, 1203, 1469
General Electric Co. 73, 74, 75, 180, 188, 194, 294, 296, 300, 305, 306, 439, 555, 659, 671, 779, 784, 786, 788, 793, 933, 1053, 1071, 1317, 1324, 1335, 1457, 1461, 1464, 1470
General Electric X-ray Corp. 300, 1308
General Power Plant Corp. 1318
General Precision Laboratory, Inc. 1060, 1203
General Radio Co. 304, 307, 550, 1060, 1326
General Scientific Equipment Co. 912
Genisco, Inc. 305, 916
Gertsch Products 435
Gest, Clifford H. 1292
Ghirardi, Alfred A. 1477
Giannini & Company, G. M. 682, 1057
Gilmore Technical Associates 781
Ginsel, Dr. L. A. 331
Givens, H. C. 164
Glass, J. A. 710
Globe-Union, Inc. 1201
Gordon Co., Claud S. 193, 778
Grace, Jr., E. J. 405
Graham-Mintel Instrument Co. 1453
Grant Pulley & Hardware Company 1205
Graphic Calculator Co. 318
Graydon Smith Products Corp. 782
Greiner Co., Emil 60, 320, 668, 918, 934, 1328, 1465, 1471
Grieve-Hendry Company, Inc. 1194
Griswold Mfg. Company, F. T. 673, 926, 1320
Gulton Mfg. Co. 305
G-V Controls, Inc. 312

H

Hacker & Co., Wm. J. 182
Hagan Corporation 668, 778
Hall, Malcolm B. 886
Haledy Electronics Co. 1336
Halross Instruments Corporation 780
Hamor, William A. 891
Hankison Corporation 1057
Hanna Engineering Works 196
Hanson-Gorrill-Brian, Inc. 1184
Hardway, Jr., E. V. 763, 1095
Hardy Instrument Co. 312
Harrop, James 1168
Hart Manufacturing Co. 1469
Hart, Porter 158, 174
Harvard University, Computation Lab. 1476
Hastings Instrument Co. 187, 437, 548, 920, 1316
Hauser Machine Tool Corp. 300
Haydon Co., A. W. 1328
Haydon Mfg. Co., Inc. 1073
Hedlin, J. P. 884
Heinemann Electric Co. 1076
Heise Bourdon Tube Co., Inc. 444
Helipot Corporation 683
Hellige, Inc. 443
Hermaseal Co., Inc. 1470
Heuschkel, J. 1034
Hevi Duty Electric Co. 1457
Hewlett-Packard Co. 66, 188, 303, 681, 927, 1072, 1324
Heye, B. F. 38, 171
Hickok Electrical Instruments Co. 189, 308, 670, 927, 929
Hluchan, S. A. 585
Holzbock, W. G. 402
Horvat, Raymond J. 410
Howe Scale Company 430
Howe, Wilfred H. 1434
Hufco Industries 940
Huggins Laboratories 1471
Hughes, R. H. 1352
Hunter Packing Company 575
Hurley, Jr., R. L. 1425
Hycon Mfg. Co. 67
Hycor Company 436
Hydraulic Controls Company 447

I

Inductograph Products Inc. 1190
Industrial Control Company 681, 925, 1459
Industrial Devices, Inc. 69, 317, 684
Industrial Electronics, Inc. 65
Industrial Instruments, Inc. 317
Industrial Nucleonics Corp. 550
Industrial Timer Corp. 565
Industrol Corp. 77
Instron Engineering Corporation 1321
International Rectifier Corp. 191, 1202
International Register Company 915
International Resistance Company 1078

J

Jacobs, Robert B. 468
Jerguson Gage & Valve Co. 553
Johns-Manville 1332
Johnson Company, E. F. 936
Johnson, J. Richard 1477
Johnson Service Co. 64
Johnson-Williams, Ltd. 182
Jones, H. E. 710

K

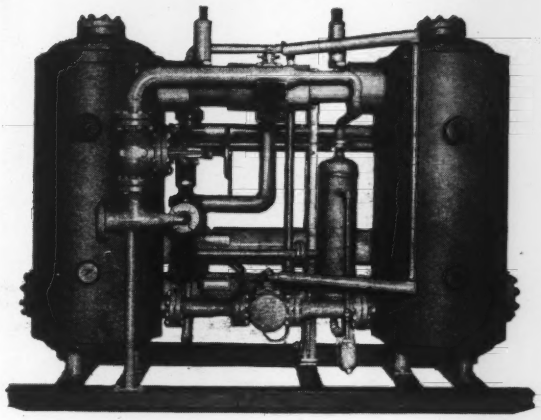
Karn Chemical Equipment Co. 562
Kay Electric Co. 184, 186, 304, 550, 672, 786, 1060, 1324
Keithley Instruments 187, 1062
Keller Tool Company 1465
Kent Cliff Laboratories 559
Kepco Laboratories, Inc. 566, 929, 1323
Kester Solder Co. 1470
Kidd, Wilmot 1494
Kidde & Co., Inc. Walter 426
Kieley and Mueller 76
King, R. C. 158, 174
King Engineering Corp. 320
Kinney Mfg. Company 560
Kirkland Co., H. R. 1326
Klopsteg, Paul E. 153
Knopf Instrument Co. 1335
Krogh, A. E. 590
Krohn-Hite Instrument Co. 434, 1189, 1100, 1191, 1323
Kushner Laboratories, Joseph B. 920

L

Labelon Tape Company 936
Laboratory Industries, Inc. 445, 1069, 1472
LaJoy, Millard H. 406
Lampkin Laboratories, Inc. 1460
Landsverk Electrometer Co. 191, 192, 315, 923, 1067, 1198, 1199
Laserson, Gregory L. 156
Lauks Sentry Products 1058
Lear, Incorporated 926
Ledeen Mfg. Company 1184
Leeds & Northrup Co. 182, 300, 302, 304, 309, 698, 778, 1057, 1214, 1316
Lenkurt Electric Company 784, 1458
Leonard Electric Co., Ward 311
Leslie Company 448
Librascope, Inc. 789
Liquidepth Indicators, Inc. 1332
Liston-Folb Instrument Co., Inc. 433
Littlefuse Incorporated 1204
Littlejohn, Jr., H. F. 1477
Lloyd, Edward C. 154
Lor-Ann Instrument Co. 184
Lord Mfg. Co. 78
Loucks, Roger Brown 30
Loudon Instruments, Inc. 185
Lovins Engineering Co. 196
L. and R. Manufacturing Co. 678

M

Mabey, Charles A. 280
Machlett & Son, E. 441, 442
MacLeod and Hanopol, Inc. 552
Macurdy, Lloyd B. 530
Magnetic Amplifiers, Inc. 311
Mallory & Co., Inc., P. R. 1202
Marchment, W. T. 42, 171
Marconi Instruments, Inc. 1062, 1187, 1188, 1190
Markson, A. A. 647
Marman Products Co., Inc. 1204
Masheter, W. L. 597
Massachusetts Institute of Technology 202
Maxson Corporation, W. L. 680
Mayer, Robert W. 1477
MB Mfg. Company, Inc. 1186
McColpin-Christie Corp., Ltd. 1454
McDonnell and Miller, Inc. 76, 675, 1462
McIntyre, A. R. 408
McMahill Colorama Company 1320
McMahon, J. B. 470, 1094
Mead Specialties Co. 313
Measurements Corporation 1060
Mechanical Products Corp. 1334
Meriam, Charles 231
Merz Engineering Inc. 922
Metron Instrument Company 443, 671, 931, 1070
Meyer-Opticraft, Inc. 426
Micro Metallic Corporation 443, 682
Micro Switch 1077, 1329
Midwestern Geophysical Laboratory 64
Miller Motor Company 925
Miller & Sons, R. F. 1458
Millivac Instrument Corp. 550
Mine Safety Appliances Company 575, 1180
Minneapolis-Honeywell Reg. Co. 60, 180, 302, 426, 548, 554, 784, 791, 912, 1056, 1314, 1452, 1468
Mittelmann Electronics Div., Century America Corporation 1184
Moisture Register Company 933
Morey, Francis C. 528
Morgan Instruments Company 1198
Multi-Amp Corporation 1324



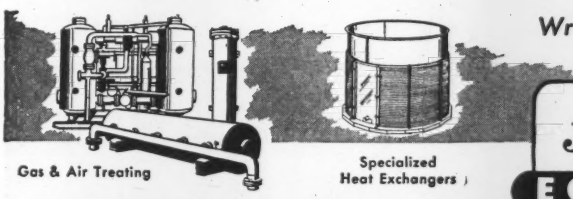
UNEXCELLED—
FOR DEHYDRATION
OF INSTRUMENT AIR!

The Pritchard HYDRYER*

The Pritchard HYDRYER* is *unexcelled* for dependable dehydration of air for instrument and process controls. Dual adsorbers provide continuous drying action. Standard packaged units designed to reduce dew points of compressed air or other gases to minus (–) 40°F. Only service connections are required. Specially designed HYDRYER* units can be tailored to your individual requirements. Investigate today!

*Registered Trade Name

Write Today for Bulletin No. 16.0.080



Producers of QUALITY Specialized Process EQUIPMENT

J.F. Pritchard & Co.

EQUIPMENT DIVISION

Dept. No. 154 — 908 Grand Ave., Kansas City 6, Mo.

District Offices: CHICAGO • HOUSTON • NEW YORK • PITTSBURGH
TULSA • ST. LOUIS • Representatives in Principal Cities from Coast to Coast

N

Nankervis Co., George L. 319
National Bureau of Standards 29, 198, 288, 572, 656, 692, 696, 700, 773, 898, 1050, 1053, 1212, 1306, 1308, 1342, 1343, 1446, 1448
National Instrument Co. 1464
Nelson and Street 303
Neomatic, Incorporated 1076
New Hermes, Inc. 789
Niagara Electrical Instrument Co. 668
Niles-Bement-Pond Co. 72
Nilsson Gage Company 441, 1319
North American Philips Co., Inc. 72, 1320, 1321, 1461
Northrop Aircraft, Inc. 912
Novak, A. V. 160
Nuclear Development Laboratory 1460
Nuclear Instrument & Chemical Corp. 189, 687, 1460
Nuclear Products Co. 1336
Nuclear Research Corp. 1460
Nuclear Research and Development, Inc. 314, 787, 1068, 1199

O

Offner Electronics Inc. 668
Ohmite Mfg. Company 683
Optical Film Engineering Company 931

P

Pacific Transducer Co. 1454
Palmer Thermometers Inc. 677
Panalarm Products Co. 68, 71
Panoramic Radio Products, Inc. 927
Panray Corp. 73
Parsegian, V. L. 1295
Partridge, Frank M. 717, 1361
Patton, R. L. 1424
Peckham, J. W. 1235
Pedersen Electronics 786
Pelletiere, J. A. 1424
Penfield Mfg. Co., Inc. 1194
Percy, J. W. 766
Perkin-Elmer Corp. 184, 1056, 1057, 1187
Perkins, George D. 221
Perry, Jr., Joseph A. 279
Phaostron Company 1466
Phen-Trols, Inc. 779
Philbrick, George A. 1494
Phillips & Hiss Company 1058
Phillips Petroleum Co. 79
Photographic Products, Inc. 915, 1452
Photoswitch, Inc. 935, 1065
Pickett & Eckel, Inc. 1066
Polarad Electronics Corp. 65, 1074
Polaroid Corp. 77
Potter & Brumfield 311
Potter Instrument Co. 180, 1210, 1326
Powers Regulator Company 1057
Precision Apparatus Co., Inc. 68, 783
Precision Radiation Instruments 787
Precision Scientific Company 674
Precision Thermometer & Instrument Co. 300
Production Instrument Co. 194, 556, 1318
Pyramid Instrument Corp. 785

R

Radiation Counter Laboratories 557, 1067
Radioactive Products, Inc. 440
Radio Corp. of America 313, 554, 677, 772, 928, 1057, 1073, 1178, 1187, 1322, 1325, 1459
Radke, A. O. 811
Rattray & Co., Inc., George 307
Raytheon Manufacturing Company 773
R. C. Scientific Instruments Co. 439
Refrigerator Car Research 811
Reinhart, F. W. 1306
Republic Flow Meters Co. 61
Reynolds Metals Company 780
Richardson, C. A. 811
Rimat Machine Tool Co. 559
Rimbach, Richard 203, 1043, 1289
Riverside Metal Company 916
Robertshaw-Fulton Controls Company 668
Robinson, Charles F. 221
Rochester Electronics Company 677, 687
Rochester Gas & Electric Corp. 1345
Rockwell, R. A. 168
Ross, H. R. 345
Ross Operating Valve Co. 447, 563
Roy Company, Milton 560
Royal Dutch Airlines 572
R-S Products Corp. 76, 446, 791
Rubicon Co. 302
Ruge-deForest Inc. 1466
Ruska Instrument Corp., 1316
Russell, Burdsall & Ward Bolt and Nut Co. 1448
Rutherford Electronics Co. 65, 302, 1189, 1456

S

Saart, Kraemer & Hanscom, Inc. 1320
St. John X-Ray Laboratory 441
Sarcotherm Controls, Inc. 430, 444
Saunders, James B. 1343
Saxl Instrument Company 442
Schaar and Company 674
Scherr Company, Inc., Geo. 1320
Schulz, George J. 534
Scott, Inc., Hermon Hosmer 1062
Selas Corp. of America 562
Selby, M. C. 572
Servomechanisms, Inc. 304
Servo-Tek Products Co. 306
Sessions Clock Company 1468
Shafer, J. R. 1507
Shallcross Mfg. Company 1079, 1203, 1466
Sheffield Corporation 1192, 1319
Shepard Laboratories 780, 1202, 1458
Sierra Products Company 1069
Silsbee, Francis B. 35
Simpson Electric Co. 67, 308
Skinner Chuck Company 1186
Smith Corp., A. O. 180
Socony Paint Products Company 1306
Sola Electric Company 782
Soldering Specialties 567
Soreng Mfg. Corp. 1073
Sorensen & Co., Inc. 1458
Southern California Meter Assn. 1477
Southwestern Industrial Electronics Co. 304
Special Instruments Laboratory, Inc. 670
Specialties Company 656
Spellman Television Corp. 70, 187
Sperry Gyroscope Company 1318
Sponge Rubber Products Co. 563
Sprague Electric Company 438, 683, 921
Squires Company, C. E. 558
Standard Oil Co. of California 806
Standard Transformer Corp. 1201
Stanford University 773
Statham Laboratories, Inc. 1200
Steel City Testing Machines, Inc. 73, 780
Sterling Instruments Company 563, 781, 1325
Stevens Mfg. Company, Inc. 444, 1463
Stewart-Warner Corp. 310, 932
Sticht Co., Inc., Herman H. 1456
Stillwell, H. R. 710
Stocker & Yale, Inc. 1471
Streeter-Amet Co. 62, 1056
Struthers-Dunn, Inc. 310
Stupakoff Ceramic & Mfg. Co. 1334
Superdraulic Corporation 782
Superior Controls Co., Inc. 1184
Superior Electric Co. 1469
Superior Instruments Company 1062
Swartwout Company 558, 561, 1314
Swedish Gage Co. of America 72
Synchro-Start Products, Inc. 78
Sylvan Electronic Labs., Inc. 1191
Sylvania Electric Products Inc. 1446
Synchroscope Company 561

T

Tartakstolle Electronics, Inc. 934
Taylor Instrument Cos. 60, 1090, 1314
Technical Appliance Corporation 934, 1075, 1077
Techno Instrument Co. 300
Teletronics Laboratory, Inc. 1188
Tel-Instrument Co., Inc., 1073
Tempil Corporation 930, 1335
Tenney Engineering, Inc. 316
Tensor Electric Development Co., Inc. 308
Testa Mfg. Company 676
Texas Company 1180
Thermo Instruments Co. 63
Thomas, B. W. 161
Thomas, William A. 410
Thomson Industries, Inc. 1333
Tinius Olsen Testing Machine Co. 302
Toeller, Heinrich 1170
Tork Clock Company 1188
Tracerlab, Inc. 191, 924, 1067, 1196, 1199, 1460, 1461
Transvision Inc. 1460
Triplett Electrical Instrument Co. 186, 305, 435
Troke, Robert W. 400, 535
Trumbull Electric Co. 296
Tyson, B. F. 1446

U

Ultrasonic Engineering Company 671, 673
United Lacquer Mfg. Co. 196
United States Gasket Co. 1467
U. S. Coast and Geodetic Survey 200
U. S. Engineering Co. 190
United States Instrument Corp. 1330
United Technical Laboratories 1200, 1331, 1467

V

Valpey Crystal Corp. 678
Van Dyke Instruments, Inc. 438, 1202
Vanton Pump Corp. 318
Veeder-Root Inc. 1058
Velock, L. H. 769
Vereins Deutscher Ingenieure 1310
Vibration Specialty Company 923, 1064
Vickers, Inc. 61
Victoreen Instrument Co. 74, 75, 924
Visi-Trol Corporation 780

W

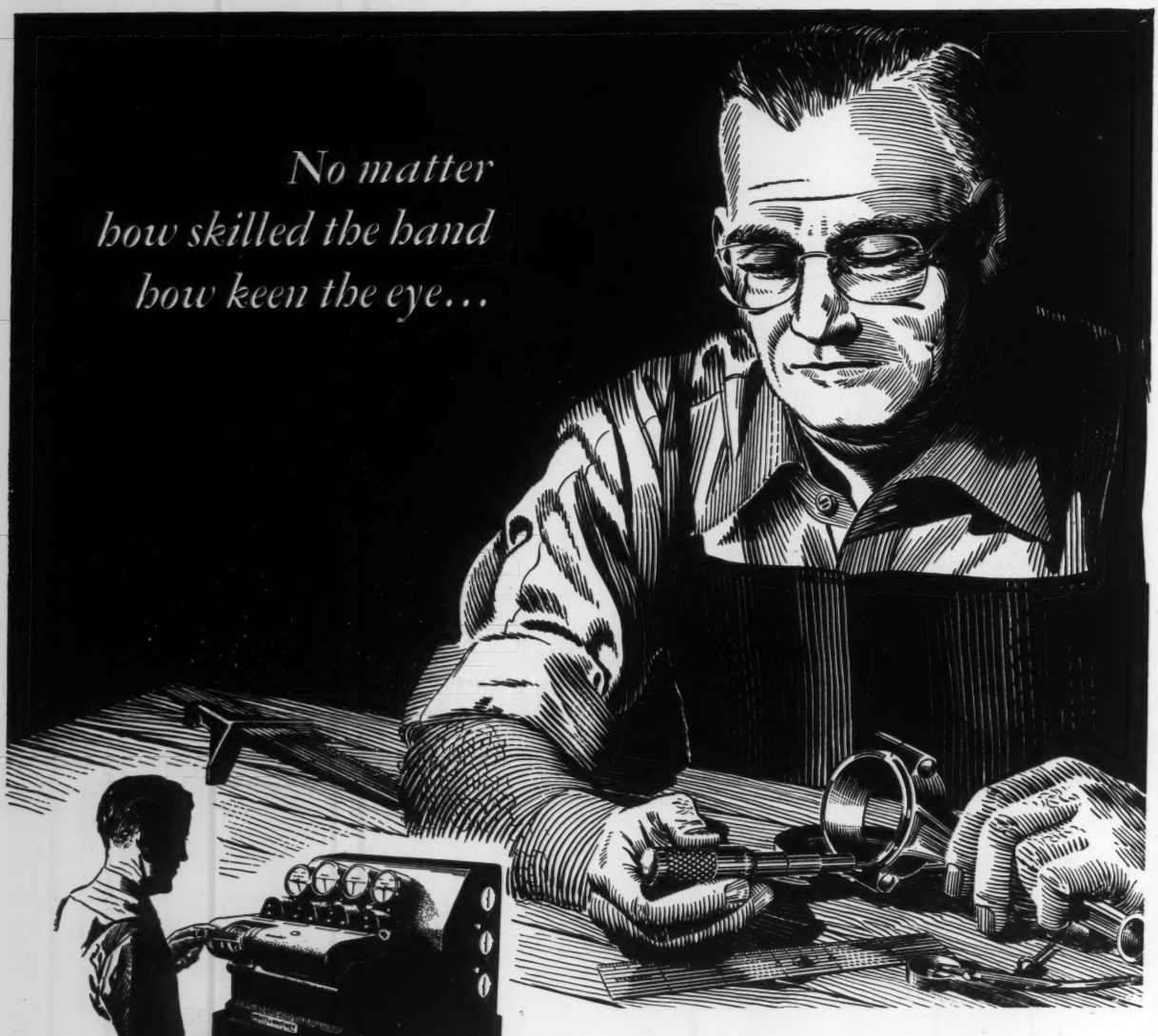
Wabash Metal Products Co. 1196, 1321, 1473
Walkirt Company 557
Ward Leonard Electric Co. 1075
Warner, D. K. 877
Warrick Company, Charles F. 1318
Washburn, Harold W. 221
Weatherhead Company 1462
Weiller Instrument Corp. 434, 436, 1452, 1454
Weissman, J. G. 1446
Welch, J. T. 652
Welch, R. J. 1306
Werey, R. B. 1430
West Shore Laboratories 63
Western Electro-Acoustic Laboratory 64, 65
Western Lithograph Co. 318
Westinghouse Electric Corp. 60, 65, 301, 780, 1456
Weston Electrical Instrument Corp. 310, 430, 548, 675, 778, 779, 896, 933, 1056, 1187, 1306, 1455
Wexler and Associates, A. 1306
Wheelco Instruments Company 426
Wiegand Company, Edwin L. 1322, 1464
Wilkerson Corporation 559
Wilkor Products, Inc. 439
Willer Sales Company 779
Wilson & Company, C. G. 564

Y

Yardney Electric Corp. 1332
Yarnall-Waring Co. 77
Young, A. J. 1172

Z

Zenith Electric Company 564, 566
Zernickow Co., O. 182
Ziebolz, H. 650



No human sense can approach the accuracy of scientific measurement.

Progress and profits in manufacturing are profoundly dependent upon instruments . . . those myriad devices that constantly work to reduce waste, to insure purity and quality and as near perfect mechanical performance as it has been given mankind to achieve.

This advertisement published as a public service by

INSTRUMENTS Publishing Company

Pittsburgh 12, Pennsylvania

This advertisement created for INSTRUMENTS by Hugh H. Graham & Associates, Inc., New Britain, Connecticut, advertising agency for Haydon Manufacturing Co., Inc., International Instruments, Inc., Sperry Products, Inc. and The Superior Electric Co.

Reprinted from *Dun's Review*, October 1951

INSTRUMENT ELECTRONICS

By MILTON H. ARONSON
Managing Editor, *Instruments*

VI. GAS-FILLED TUBES

A GAS-FILLED tube, or *gas tube*, is a vacuum tube in which a small amount of gas—usually mercury vapor, nitrogen, neon, argon, or xenon—is introduced. As the gas is at low pressure, the gas tube is a low-vacuum tube with gas in it.

Gas tubes are available as diodes, triodes, and tetrodes. The triodes and tetrodes are called *thyratrons*. Hot-cathode diodes (Fig. 6-1) are called *phanotrons*. Fig. 6-2 shows the

Fig. 6-2. Symbols for gas tubes. A, hot-cathode diode, or phanotron; B, triode, or thyratron; C, cold-cathode glow tube, or VR tube; D, neon glow tube; E, mercury-pool tube, or ignitron.

schematic symbols for typical gas-filled tubes. The small dot in the circle indicates that the tube is filled with gas.

Comparison with Vacuum Tubes

Current-carrying Ability

The gas tube overcomes the primary disadvantage of vacuum tubes, which is low current. The plate current of the vacuum tube is limited by the ability of the cathode to emit electrons. For example, two type-6L6 beam-power pentodes in push-pull can produce only about 50 watts (200 ma. at 250 volts) of output power. Most gas tubes, however, can deliver currents of many amperes at higher voltages because the gas is a source of electrons. The gas tube has many industrial applications because of its ability to rectify and control large currents.

Efficiency

As the gas tube can deliver higher current with less voltage drop between cathode and plate, the *plate resistance* of gas tubes is lower than that of vacuum tubes. For example, the plate resistance of most gas tubes is less than 20 ohms, and remains constant for wide variations in current; the plate resistance of vacuum tubes is much higher—hundreds or thousands of ohms. As the *IR* drop between cathode and plate is a loss of power within the tube, the efficiency of gas tubes is much higher than that of vacuum tubes.

ANSWERS TO QUIZ V.—VACUUM TUBES

5-1.	(b)	5-7.	(d)	5-13.	(d)	5-19.	(c)	5-25.	(b)
5-2.	(c)	5-8.	(b)	5-14.	(d)	5-20.	(a)	5-26.	(a)
5-3.	(d)	5-9.	(a)	5-15.	(a)	5-21.	(c)	5-27.	(d)
5-4.	(c)	5-10.	(a)	5-16.	(c)	5-22.	(b)	5-28.	(a)
5-5.	(c)	5-11.	(c)	5-17.	(b)	5-23.	(a)	5-29.	(d)
5-6.	(a)	5-12.	(b)	5-18.	(a)	5-24.	(b)	5-30.	(c)

Test items for VI. Gas-filled Tubes—page 79.

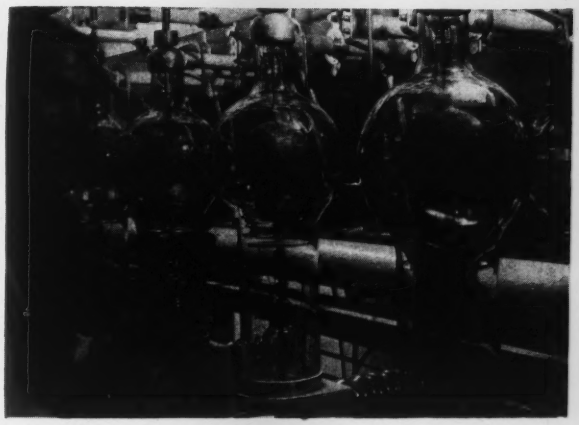


Fig. 6-1. Bank of large mercury rectifier tubes. (Courtesy Westinghouse Electric Corp.)

Grid Control

Both vacuum tubes and gas tubes can have a grid which, because it is near the cathode, controls the electrons emitted from the hot cathode. A basic difference between a gas tube and a vacuum tube is that the control grid in the vacuum tube can control the plate current at all times. In the gas tube, however, the grid can control the point at which the gas ionizes and the plate current begins, but thereafter it loses control of the plate current. For this reason, gas tubes are limited in application to circuits in which the grid can lose control of plate current for at least a part of each cycle of applied a.c.

Ionization

Electrons moving from the cathode to the plate in a gas tube collide with gas molecules. The collision causes the gas molecule to eject one or more of its orbital electrons. Electrons ejected from a molecule join the stream of electrons traveling toward the plate. As they move, they cause more collisions, which liberate still more electrons. This is a chain reaction which rapidly causes the plate current to reach a maximum value limited only by the load impedance or the tube elements.

Molecules that lose electrons are positive *ions*. The process of ejecting electrons from molecules is called ionization. An ionized gas-filled tube contains molecules, ions, and electrons within the envelope. The electrons in the tube, which are greatly increased in number by the process of ionization, travel rapidly to the plate. The heavier positive ions move slowly to the negative cathode.

In a vacuum tube, the space charge around the hot cathode limits the number of electrons emitted from the cathode. This is why the grid can control the plate current. In the gas tube, however, the positive ions reach the vicinity of the cathode and neutralize the space charge. Thus, when the gas is ionized, the cathode can emit as many electrons as it is capable of emitting (saturation current). This is why a gas tube has low plate resistance, and why saturation can flow as soon as the gas is ionized. Of course the current that does flow depends on the load put in series with the tube.

Ionization Potential

An electron must strike a gas molecule with high velocity before it can eject electrons from the molecules of gas. As it is the potential between the plate and the cathode which accelerates the electrons, this potential must reach a certain level before ionization can begin. The minimum plate voltage required to start ionization is a control characteristic called the ionization potential, or the *firing point*, of the tube. When ionization occurs, saturation current can flow as long as the plate potential is high enough to sustain the ionization process.

Extinction Potential

Once ionization starts, it continues even if the plate potential is reduced considerably below the firing point. However, if the potential is reduced to a very low value the ionization stops, the gas deionizes, and current conduction stops. This low potential at which current stops is known as the *extinction potential.* The extinction potential makes it possible to use a gas tube as an electronic switch. Some plate voltages permit current to flow; lower plate voltages block current flow. Another way of expressing the same thing is to say that the plate potential controls the plate resistance—the gas tube has almost infinite plate resistance when the plate voltage is too low to fire the tube, and it has a low plate resistance when the tube conducts. Thus the tube is like an efficient on-off switch that can be controlled by the plate voltage.

Inverse Voltage Rating

As in vacuum tubes, the current in a gas tube should flow only from cathode to plate. The maximum negative voltage that you can apply to the plate of a gas tube before reverse current flows—that is, the *peak inverse voltage rating* of the tube—is specified in the tube information sheets for that type of tube. When using gas tubes, never apply an a-c. voltage that exceeds the specified peak inverse voltage. Reverse current, or arc-back, can ruin the rectifier because the tube is a low resistance on both halves of the applied a-c. cycle, thus increasing the power dissipated in the tube.

The inverse voltage rating of a gas tube decreases as the frequency of the applied alternating voltage increases. This is because the positive ions normally recombine with electrons (and thus neutralize themselves) during the nonconducting half cycle. At high frequency, the ions have less time to deionize themselves before the peak inverse voltage is applied across the tube.

Ionization and Deionization Time

In fast-acting circuits, as in radar pulsing, triggering circuits, radiation particle counting, etc., the time for the gas to ionize and deionize is important. Ionization time is the time for the gas to ionize after the proper voltages are applied suddenly. Similarly, deionization time is the time required for the gas to deionize when the plate voltage is removed suddenly. Although both times are in the order of microseconds, the deionization time is several times longer than the ionization time.

Gas-filled Diodes

A gas-filled diode (Fig. 6-2,A), like a vacuum-tube diode, has a plate and a cathode. There are two types of gas diodes—cold-cathode diodes and hot-cathode diodes.

Cold-cathode Tubes

The neon glow lamp (Fig. 6-2,D) is a cold-cathode gas-filled diode. When the cathode and the plate have the same shape, size, and construction the tube can conduct equally well in either direction (depending only on the polarity of the applied potential) because both electrodes are equally good emitters of electrons. When one electrode is many times larger than the other (Fig. 6-2,C) the larger electrode (which is the better emitter) becomes the cathode. The tube then conducts better in one direction.

As a cold cathode emits no electrons, the ionization process cannot be started by electrons emitted from the cathode. The process is started by the few electrons and ions that are produced by cosmic-ray and other atmospheric ionization effects. As there are not many electrons to start the ionization, the firing potential for cold-cathode tubes is higher than that for hot-cathode tubes. The neon glow lamp is somewhat erratic in operation because the firing potential varies from time to time.

The glow tube gets its name from the glow that is produced at the cathode when current passes through the tube. The glow is caused by the recombination of positive ions with emitted electrons. The color of the glow depends on the gases that are mixed with the neon in the tube.

The glow is produced only at the cathode, or negative electrode, where the ions combine with electrons. However, when alternating voltage is applied to the electrodes of a neon glow lamp, both electrodes are surrounded with the glow discharge because each electrode becomes a cathode on alternate half cycles.

A radio-frequency field can cause a glow lamp to ionize. Therefore, neon lamps sometimes are used to detect a high-power r-f. field. When using a glow tube to detect an r-f. field, first tape the glow tube to an insulating handle and then bring the glow tube near the resonant tank or transmitting antenna that you wish to check. As dangerously high d-c. voltages are generally used near high-powered r-f. circuits, the handle keeps you from touching the circuit.

The glow tube as a voltage regulator.—Another important use of glow tubes is as a *voltage regulator.* When

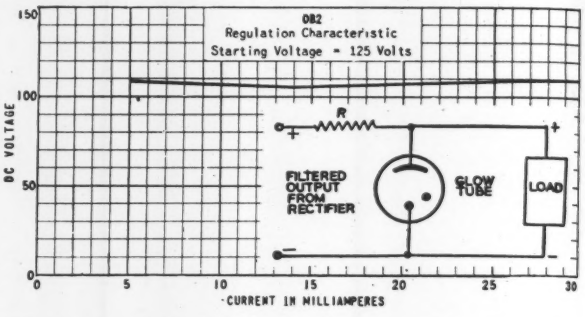


Fig. 6-3. Regulation characteristic of a VR tube, and typical circuit.

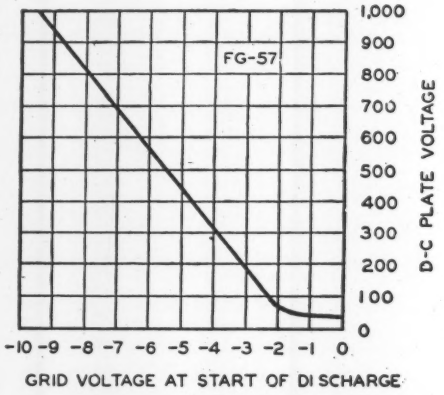


Fig. 6-4. Grid-control characteristic of a thyratron.

a gas is ionized the voltage drop across the tube is constant even when the current through the tube varies. Therefore, glow tubes are used widely as voltage regulators in power supplies. Typical glow-discharge tubes for voltage regulators are (1) the OA3, or VR75, (2) the OB3, or VR90, (3) the OC3, or VR105, and (4) the OD3, or VR150. These tubes have different gases in them. The gas in the VR75 causes a 75-volt drop across the tube when ionized; the gas used in the VR105 causes a 105-volt drop; that in the VR150 causes a 150-volt drop.

Fig. 6-3 shows a typical voltage-regulating circuit, and also the characteristics of the tube. Note that the voltage across the tube remains constant for a 25-ma. current change through the tube—from 5 to 30 ma. The dropping resistor is used to limit the maximum tube current to 30 ma. The regulation is done by the tube and the dropping resistor. If a change occurs in either power-supply voltage or load resistance, more or less current flows through the gas tube, but the output voltage remains constant.

Glow tubes are used also as sources of light, as current controls, and as rectifiers. As the voltage drop across cold-cathode tubes is much higher than that across hot-cathode

gas tubes, the former is less efficient and can not be used to rectify high currents.

Hot-cathode Diodes

The hot-cathode gas-filled diode, or *phanotron*, is designed for use only as a rectifier (Fig. 6-2,A). Tubes of this type generally use argon or mercury vapor as the gas. They are highly efficient, have low voltage drop from plate to cathode (less than 15 ohms), and can supply high current (up to hundreds of amperes).

A bank of large high-voltage mercury rectifier tubes is shown in Fig. 6-1. In the mercury-vapor rectifier a small amount of liquid mercury is in the tube. The gas is formed when the hot cathode vaporizes a small amount of the liquid mercury. As these tubes cannot supply their rated output until the mercury is vaporized completely, the heater potential must be turned on first. Enough time must elapse for the liquid mercury to become vaporized before the plate voltage is turned on. Thermal time-delay relays can be used to perform this timing function.

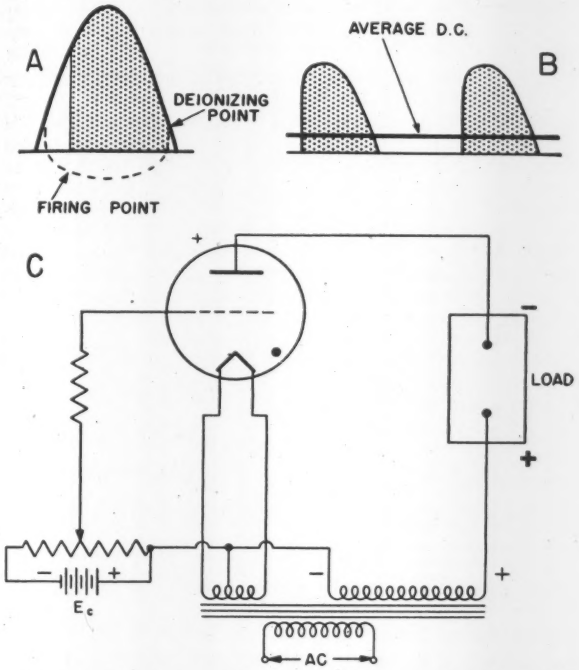


Fig. 6-5. Thyratron operation; A, applied a-c. plate voltage and critical grid bias; B, average rectified d.c. through load; C, circuit showing alternating voltage applied to plate.

Gas-filled Triodes

A gas-filled triode (or tetrode) has a grid that can control the firing point, as shown in Fig. 6-2,B. This type tube is called a *thyratron*. The ionization is started by a small current from the heated cathode. The grid near the cathode controls this small starting current, and hence the firing point. The grid-control characteristic of a typical thyratron is shown in Fig. 6-4. Note that a grid voltage of minus 4 volts (or higher) can fire the tube if the plate voltage is 300 volts or more.

When the grid of a thyratron initiates the plate current, the current suddenly jumps to full saturation current. After the plate current starts, the control grid has no further effect—the grid can be made considerably more negative without affecting the plate current. *To stop the plate current through the tube, the plate voltage must be reduced below the extinction point, or the plate circuit of the tube must be broken.*

The grid loses control because the positive ions in the tube are attracted to the negative grid, thereby destroying its negative potential and its controlling action. Other ions are attracted to the cathode and neutralize the space charge. Therefore, once ionization starts, there is no space charge to limit the current and no negative grid to control the current—the tube thus passes maximum current.

The thyratron usually has alternating voltage applied to its plate, as shown in Fig. 6-5. The tube can conduct only on the positive half cycles of the applied a-c. plate voltage; on negative half cycles the tube is cut off because the gas deionizes. Thus the negative half cycle is used to deionize the tube. A signal applied to the grid can control the firing point and, therefore, the amount of time the tube conducts on the positive half cycles.

The *critical bias*, or the grid bias necessary to fire the tube at the applied plate voltage, is shown by the dotted line in Fig. 6-5,A. The heavy curve in Fig. 6-5,A is the applied a-c. plate voltage. By applying a positive signal to the grid the tube can be made to conduct at any desired time, as shown by the shaded portion of Fig. 6-5,A. The average current through the load can be controlled by varying the portion of the conducting cycle, as shown in Fig. 6-5,B. One of the major industrial uses of thyratrons is motor control of this type.

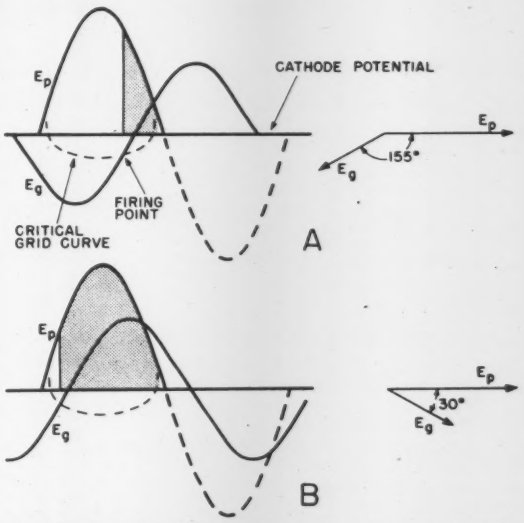


Fig. 6-6. Control of firing point by phasing of a-c. grid signal.

In practice, the conducting period is controlled by applying an a-c. signal to both plate and grid, as shown in Fig. 6-6. By phasing the grid signal, the grid potential can be made to exceed the critical bias at any point. For example, if the grid signal lags the plate signal by 155 degrees, the tube conducts for only a small portion of the cycle. When the grid signal lags by only 30 degrees, the thyratron conducts for a large part of the cycle. A d-c. motor can be controlled smoothly simply by changing the phase of the a-c. signal applied to the grid of a thyratron.

Thyratrons are used also as trigger devices, relays, and sawtooth generators. Very little energy is used by the control grid to start conduction, yet the tube can pass large currents after conduction starts.

Thyratrons used on low-frequency power, such as 60 cycles per second, usually are of the mercury-vapor type. At higher frequencies—where the ionization and deionization must be more rapid—helium, argon, and neon are used because the positive ions, which are lighter than the mercury ions, can move more rapidly and deionize quicker during the negative half cycles.

Mercury-pool Tubes

A gas tube requires an ionized gas and a cathode surface capable of supplying a large quantity of electrons. Hot-cathode gas tubes usually have an oxide-coated thermionic

Continued on page 78

Cities Service Cat-crackers at Lake Charles, La.

Problems in Refiner

The refinery control problems discussed in this interesting article include (1) priming facilities for unloading crude from barges, (2) pH control of water draw-offs, (3) steam-air decoking of furnaces, (4) reducing loss of centrifugal-compressor suction pressure, (5) controlling

Priming Facilities for Unloading Crude from Barges

VARIOUS problems are encountered in unloading crude from barges, the major one of which is obtaining and retaining suction on the pump used for this purpose. If a crude with low vapor pressure is being unloaded, the problem is encountered when stripping the last crude from the barge because air is pulled into the suction during this period. When a high-vapor crude is being unloaded, continuous vaporization occurs in the pump suction line, which materially increases the unloading time and costs.

We were requested recently to unload crude with 13-pound vapor pressure from barges. It was found practically impossible to pump this high-vapor-pressure material from the barge because the pump elevation was several feet higher than the elevation of the barge and vaporization occurred in the pump suction. Both centrifugal and reciprocating pumps were available for unloading.

To overcome this problem the suction lines to the pump were streamlined to minimize the pressure drop. This was done by replacing all sharp turns or "Y's" with long-radius turns. A vapor separator was installed in the suction of the pump to separate the liquid from the vapor. The vapors were piped to a steam ejector and exhausted to atmosphere. A liquid-level controller with a single-seated control valve was installed in the vapor line ahead of the ejector to prevent the ejector from pumping crude oil and exhausting same to the atmosphere. This system has performed satisfactorily by reducing the unloading time to ⅓ of the original. It is very desirable on unloading heavy crudes because it reduces the stripping time for the barge. The only objectionable feature of this system is a slight oil mist carryover from the ejector.

Owing to the successs of this system, we are planning to remove the reciprocating pumps originally installed for crude unloading and to install priming facilities for the other two centrifugal pumps.

pH Control of Crude-unit Overhead Water Draw-offs

pH controllers were installed on the north and south crude units during the third quarter of 1948. These instruments have improved the control of the pH on the water draw-off from these units and thereby reduced corrosion on the overhead condensers.

Leeds and Northrup instruments with wide throttling range and drift correction were used for the installation. The control valve, on which a valve positioner was installed, was manufactured by Hammel-Dahl.

Ammonia is used in the crude unit to neutralize the H_2S and HCl absorbed in the water to control the pH. The refinery has a central ammonia storage-drum from which ammonia is piped to various units. The ammonia is reduced in pressure and then is vaporized before reaching the control valve which regulates the ammonia usage to the tower. The ammonia is fed to the vapor line from the kerosene stripper. A sample of water is withdrawn continuously from the gasoline water separator through a separate line direct to the pH cell. A separate line was found necessary because the liquid-level variations caused slight changes in the pH reading when the sample was taken from the regular water draw-off line.

No difficulty has been experienced with the control of the pH; however, recording the pH presented some difficulty in the beginning. We found that if one man did all the maintenance work on the installation, much better results were obtained, probably because he became more familiar with the equipment. A dry-air bleed was installed in the cover of the pH cell to prevent moisture condensation. It was found that the pH reading was affected greatly by any tower pressure variation caused by the change in solubility of H_2S at different pressures.

Fig. 1 shows a test made on the installation to determine the dead time and capacity time of the system. All ammonia was shut off. After a 3-minute dead time, the pH started to drop. After a period of 18 minutes, it reached a minimum value. After several minutes, the ammonia was opened up. There now was a 2-minute dead time followed by a 6-minute capacity time before the pH reading lined out at or near its normal value of 7. The relatively large capacity time in relationship to the small dead time indicates that the process should be controllable.

The above test was conducted manually prior to the installation to determine if the process would be controllable.

Steam-air Decoking of Furnaces

Furnaces in which coke is deposited inside the furnace tubes are decoked by steam-air decoking. The coke is burned from the tubes by air. The temperature rise is limited by diluting the air with steam so that the operation takes place at approximately 950 degrees. The decoking is preceded by a steam-spalling period, in which steam is fed at a high rate through the furnace tubes to remove a large percentage of the coke and reduce the time required for steam-air decoking.

Many papers have been written in the past on steam-air decoking of furnaces; however, the papers we have read in the past indicated that this practice is an art rather than a science. After much debate and delay, it was decided to put in a test installation at our refinery. Our calculations indicate that the practice is a science and not an art.

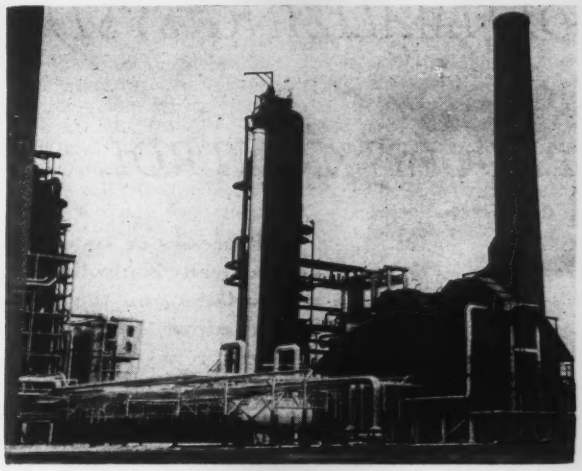
The calculations indicate that the steam-air ratio should be 10:1 (on a weight basis) to limit the temperature rise on combustion to 240 deg. F. The temperature rise is a direct function of the ratio of percent of oxygen present to the percent of inert material present in the steam-air mixture. With pure oxygen, the temperature rise is approxi-

Presented at the A & M College of Texas' Sixth Symposium on "Instrumentation for the Process Industries," Houston, Texas, Sept. 10-14, 1951.

By E. D. MARTIN
Cities Service
Refining Co.

rControl

flow of 50° Baumé caustic, (6) dual-range mercury-manometer flow-meters, (7) controlling surging of sidestream level, (8) removable thermowells and protective guards, (9) noise reduction at catalytic cracking units, and (10) mixers.



Crude-oil Unit and Furnace

mately 4000 deg. With steam, a temperature rise of zero degrees would be expected (Fig. 2).

Meters were installed on both the air and the steam, with the steam meter factor 10 times that of the air meter factor. During the burning period, the air-meter reading was kept at or below that of the steam reading. During the decoking period it was found that a small temperature rise occurred in all the tubes in the furnace, rather than a ring of fire passing successively through each tube.

A crude-oil furnace was used for the initial decoking experiment. At present, plans are being made to increase the number of installations on other furnaces.

Reducing Loss of Suction Pressure in Centrifugal Compressors

Our calculations indicated that considerable air-compressor capacity was being lost owing to the orifice plate located in the suction line. As shown in Fig. 3A, each suction line was 30 inches in diameter and 30 feet long. A short section of the intake line, 45 inches in diameter, supported the hood over the entrance. Air flow to the compressor was measured by an orifice in the suction line about 8 feet above the compressor inlet nozzle. An orifice with a d/D ratio of 0.75, flange taps, and a meter range of 20 in. of water was used. This represented considerable pressure loss in air supplied to the compressor.

To reduce pressure loss in the suction line to the compressor, the line was revised as shown in Fig. 3B. The orifice was removed and the length of 45-in. pipe was increased, replacing the 30-in. pipe from the intake to the orifice flanges. The transition piece from the 45-in. to 30-in. section of line was rolled at an angle of 15 degrees with the vertical to form the entrance cone of a venturi. The remaining part of the line remained 30 inches in diameter, forming a "partial" venturi because there was no recovery cone. However, the lack of the recovery cone did not result in additional pressure loss because the venturi pressure drop appeared as an entrance loss in the original installation.

Pressure taps were installed above the entrance cone and in the throat below the entrance cone for measuring air intake. A flow recorder with a range of 10 inches of water was used. The meter factor was calculated by using standard venturi flow calculations. A correction factor was determined after start-up from a test of all meters in the compressor discharge system.

As a result of the revisions to the compressor suction lines, the capacity of the compressors was increased by approximately 1.5 percent, with a decrease of approximately 1 percent in horsepower.

The potential earnings of the catalytic cracking units were increased by $110,000—based on air supply as the limiting factor. The cost of the revisions was less than $1,000 for the two compressors.

Controlling Flow of 50° Baume' Caustic

One section of our Treating Plant is a Unisol Unit in which it is necessary to measure and control the flow of 50° Baumé caustic. This was found rather difficult with conventional instruments because of the tendency of the caustic to crystallize and because materials deposited out of the caustic.

The original installation consisted of a conventional mercury-manometer-type flow controller with a double-seated parabolic-plug control valve. The maintenance of the mercury-manometer seals was excessive, and the control valve had a strong tendency to slowly bridge over the ports with crystallized caustic and debris until the valve was wide open, at which time a slow reduction in caustic rate occurred.

Continued on page 80

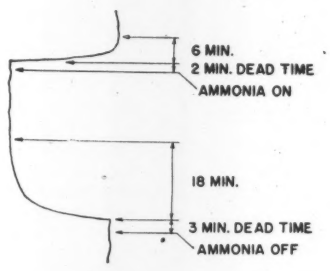


Fig. 1. Test showing dead time and response time of pH control system.

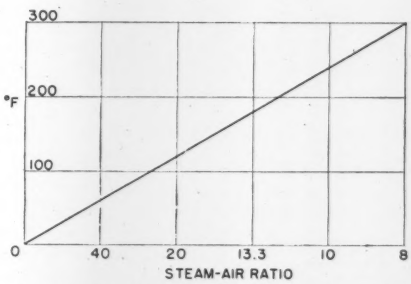


Fig. 2. Combustion temperature rise during steam-air decoking.

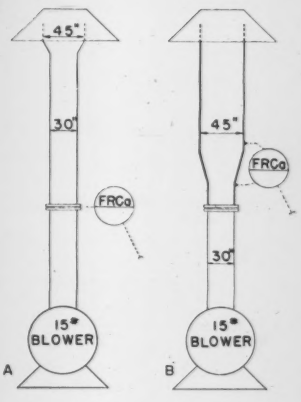


Fig. 3. Suction line to compressor. A, original; B, revised.

OPTIMALIZING SYSTEM for PROCESS CONTROL

By Y.T.LI
Massachusetts Institute of Technology

Processes or systems that have a maximum-efficiency operating point can be automatically controlled at maximum efficiency by imposing a forcing function, or test variation, on the process controller, and by using the resulting output variation to adjust the controller automatically. This technique may provide the answer to the supreme problem of industrial control—how to match the controller to the characteristics of the process. Even in "non-optimalizing" processes, the technique might provide automatic means for adjusting controller modes. This article, of great significance, is presented in three parts, of which this is the first.

Types of Control Systems

A PROCESS controller may be defined as a control system which forces an operating system to perform a certain task. In general, the purpose of an operating system is to produce a required output from a number of inputs. The operation by which the output is produced may be classified into two types. In the first type of operation the output is produced according to a predetermined, physically definable specification. In the second type of operation the output is produced with a certain optimum performance which does not have to be a known quantity.

A controller for the first type of operating system forces the output of the operating system to remain within a tolerable deviation from the specified output level. This type of controller falls into the category of a *performance-regulating controller.*

A controller for the second type of operating system forces the output of the operating system to remain within a tolerable deviation from the optimum output level, which is not readily known. A controller of this type is called an *optimalizing controller;* the entire system, including the operating system and the controller, is called an *optimalizing system.*

Presented at the A & M College of Texas' Sixth Symposium on "Instrumentation for the Process Industries," Houston, Texas, Sept. 10-14, 1951.

An Operating System With Optimalizing Control

An operating system in an industrial plant generally functions to produce a certain type of output from a number of inputs. Both the output and the essential inputs may be in the form of certain types of material or certain forms of power. The production or consumption of these materials, or this power, is the primary concern in the operation.

Fig. 1 is a functional diagram of a generalized operating system. In this system an *input convertor* is shown as the essential component of the operating system, which consumes two *actuating inputs* to produce a single *input-convertor output.* The input convertor also receives one non-consuming *modifying input.* The action of this modifying input is to change the functional relationship between the actuating inputs and the output. As shown in the figure, the actuating inputs and the modifying input are regulated by suitable *input adjustors,* and are therefore called *controlled inputs.* In addition to these three controlled inputs, there may be a number of uncontrolled inputs, sometimes called environmental inputs; these are shown by dash lines in Fig. 1. The *output coupler* in Fig. 1 receives the input-convertor output and transforms it into other useful forms of outputs.

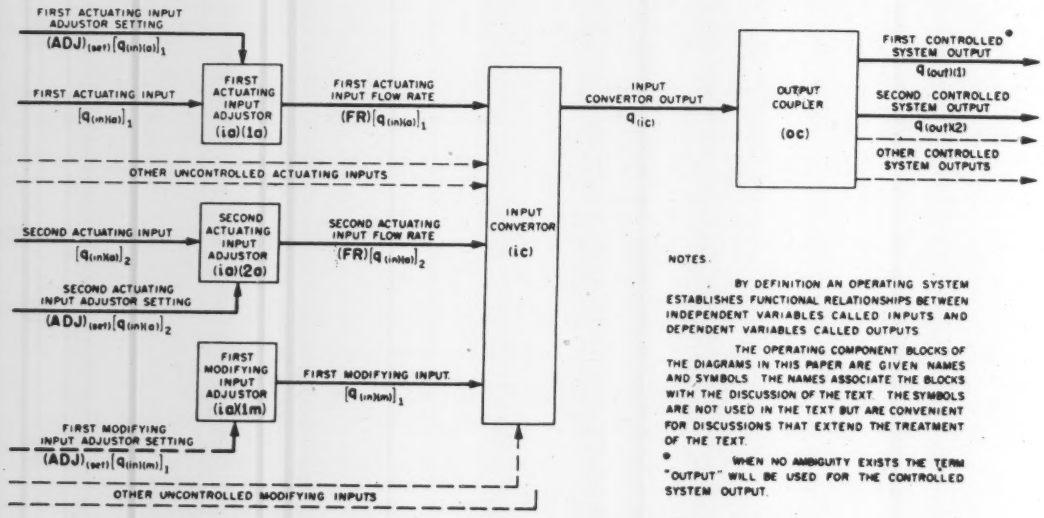

FIRST ACTUATING INPUT ADJUSTOR SETTING
$(ADJ)_{(set)}[q_{(in)(a)}]_1$
FIRST ACTUATING INPUT
$[q_{(in)(a)}]_1$
FIRST ACTUATING INPUT ADJUSTOR
(ia)(1a)
FIRST ACTUATING INPUT FLOW RATE
$(FR)[q_{(in)(a)}]_1$
OTHER UNCONTROLLED ACTUATING INPUTS
SECOND ACTUATING INPUT
$[q_{(in)(a)}]_2$
SECOND ACTUATING INPUT ADJUSTOR
(ia)(2a)
SECOND ACTUATING INPUT FLOW RATE
$(FR)[q_{(in)(a)}]_2$
SECOND ACTUATING INPUT ADJUSTOR SETTING
$(ADJ)_{(set)}[q_{(in)(a)}]_2$
FIRST MODIFYING INPUT ADJUSTOR
(ia)(1m)
FIRST MODIFYING INPUT
$[q_{(in)(m)}]_1$
FIRST MODIFYING INPUT ADJUSTOR SETTING
$(ADJ)_{(set)}[q_{(in)(m)}]_1$
OTHER UNCONTROLLED MODIFYING INPUTS
INPUT CONVERTOR
(ic)
INPUT CONVERTOR OUTPUT
$q_{(ic)}$
OUTPUT COUPLER
(oc)
FIRST CONTROLLED SYSTEM OUTPUT
$q_{(out)(1)}$
SECOND CONTROLLED SYSTEM OUTPUT
$q_{(out)(2)}$
OTHER CONTROLLED SYSTEM OUTPUTS
NOTES
BY DEFINITION AN OPERATING SYSTEM ESTABLISHES FUNCTIONAL RELATIONSHIPS BETWEEN INDEPENDENT VARIABLES CALLED INPUTS AND DEPENDENT VARIABLES CALLED OUTPUTS
THE OPERATING COMPONENT BLOCKS OF THE DIAGRAMS IN THIS PAPER ARE GIVEN NAMES AND SYMBOLS. THE NAMES ASSOCIATE THE BLOCKS WITH THE DISCUSSION OF THE TEXT. THE SYMBOLS ARE NOT USED IN THE TEXT BUT ARE CONVENIENT FOR DISCUSSIONS THAT EXTEND THE TREATMENT OF THE TEXT.
* WHEN NO AMBIGUITY EXISTS THE TERM "OUTPUT" WILL BE USED FOR THE CONTROLLED SYSTEM OUTPUT.

Fig. 1. Functional diagram showing the components of a typical operating system.

The internal-combustion engine (Fig. 2) is an example of a system with operating components that correspond functionally to those of Fig. 1. Fuel may be considered as the first actuating input, air as the second actuating input, and ignition timing as the first modifying input. The combustion chamber and swept-cylinder volume provide the input-convertor function by supplying an enclosure in which chemical energy is changed, first into heat and then into mechanical output. The output is supplied to a brake or electrical generator that acts as the output-absorbing system.

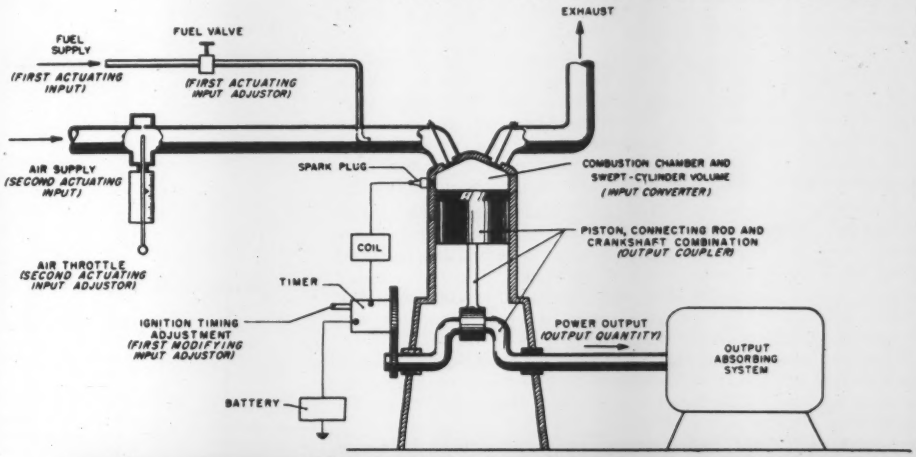


Fig. 2. A C.F.R. reciprocating-piston engine as an operating system. The C.F.R. engine is a single-cylinder test engine, developed by the Cooperative Fuel Research Committee (now the Coordinating Research Council, Inc.) for fuel rating. For details, see the C.R.C. Handbook (Coordinating Research Council, Inc., 30 Rockefeller Plaza, New York, N. Y., 1950) p. 32

of these inputs. The three-dimensional model shown in Fig. 3 has a *performance surface* that represents the relationships between brake mean effective pressure (B.M.E.P.) as the dependent output, and ignition timing and fuel-air ratio as independent variables, subject to the conditions that engine speed and fuel flow rate are both held constant. The data summarized in Fig. 3 shows that an optimum point exists at the point marked OP, which is the highest point, or the point of maximum B.M.E.P. It is this point that must be approached by changes in spark advance and air flow during the process of adjusting for

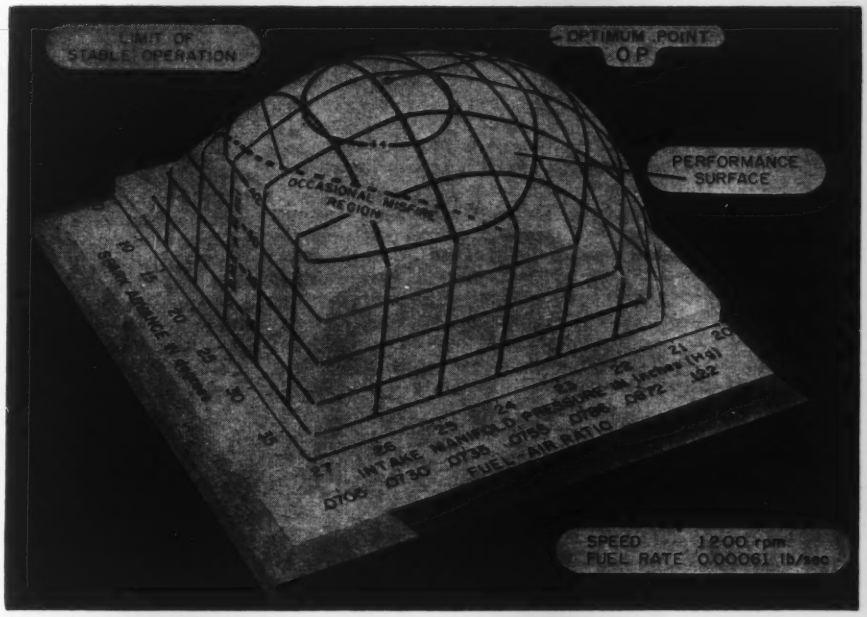


Fig. 3. Static performance characterisitics of the C.F.R. engine, showing relation between brake mean effective pressure (B.M.E.P.) as the output and ignition timing and fuel-air ratio as independent variables — for constant engine speed and fuel flow rate. The B.M.E.B. is plotted vertically.

When a given load requirement is imposed on the system, one of the actuating inputs must be adjusted to a level determined principally by the load. In order for operation to be possible at all, the other actuating inputs and modifying input must have exact relationships to this primary controlled input. The adjustments of these inputs in order to fulfill the given load condition can be made by suitable performance-regulating systems. For example, a governor and a carburetor may be used together when the load requirement is to maintain the speed of the engine at a constant level.

When the input settings are made within ranges that allow the system to function, the remaining problem is to refine the input adjustments so that the required output is obtained with minimum flow rates of the costly inputs, or the maximum output is obtained for given flow rates optimum performance with fuel flow and engine speed held constant.

To extend the description of engine characteristics at constant speed beyond that given in Fig. 3, a curve family (Fig. 4) may be plotted to show the effects of spark advance and air flow on break mean effective pressure for various fuel flow rates. Another family of curves is required to describe the engine performance at various engine speeds.

In principle, the performance characteristic surface of Fig. 3 and the curve families in Fig. 4 define the exact relationship between the input levels and the load condition. Under the assumption that it is possible to build these relationships into regulating systems, it should be possible to maintain the optimum operating condition by means of performance-regulating systems. An aircraft

carburetor, for example, is a performance regulator with a built-in device for adjusting the several important inputs for near-optimum operating conditions.

In practice, complete information on engine performance is more complicated than that given in Figs. 3 and 4. Engine performance is affected not only by the controlled inputs and the load conditions, but also by (1) the temperature, pressure, and humidity of the input air, (2) the temperature and quality of the fuel, (4) cylinder temperature, (5) exhaust gas pressure, and other environmental inputs. A performance regulator that can include all the complicated relationships between the controlled input and the environmental inputs usually is not practicable.

The principle of the optimalizing-control system discussed in this article is to search out the optimum point, such as that shown in Fig. 3, by utilizing the nonlinear performance characteristics between the output and the controlled inputs. It is assumed that the operation is independent of the complicated relationships of the controlled input to load conditions and environmental inputs.

Optimum performance through optimalizing control can be accomplished frequently by manual means. An operator, with the aid of a suitable output indicating system, such as a torque meter, can progressively adjust the ignition timing and fuel-air ratio to proper settings for optimum output. In principle this process, in which the operator makes manual adjustments, is a feedback operation. The operator correlates the information of the torque meter with the input adjustments he has made to determine the additional adjustment required. Humanly-controlled operating systems are necessarily slow in response, and they are generally not satisfactory or practicable in many operations.

An optimalizing-control system operates in principle like the human-controlled system described. However, in the optimalizing-control system an automatic controller replaces the human operator in the feedback loop. The observation and correlation of the output with the controlled-input adjustment, and the cut-and-try process exercised by the human operator, are functions of the controller.

Fig. 5 is a functional diagram showing the important components of a generalized optimalizing-control system adjusting a single controlled input, hereafter referred to as the input. In this system the input adjustor is operated by the optimalizing controller to have a certain ever-changing function. The output variation caused by the input variation is received by the output receiver, and an output signal that is correlated with the input variation is produced by the correction-signal generating system. The result of the correlation is to generate a correction

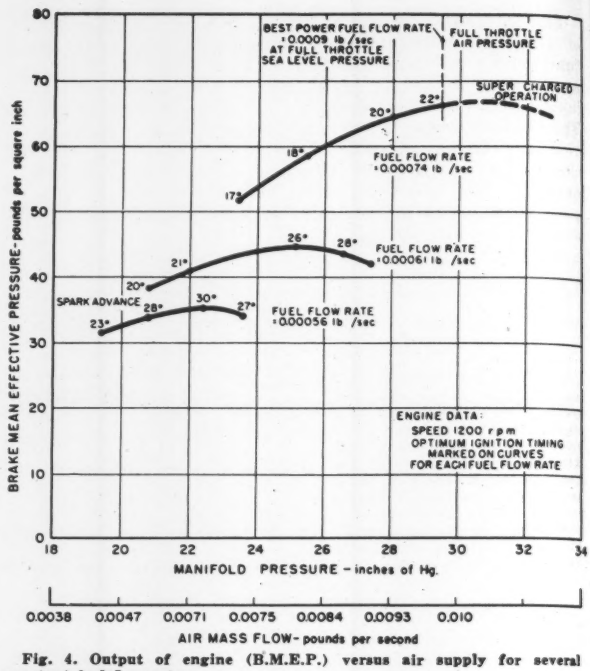

BEST POWER FUEL FLOW RATE = 0.0009 lb/sec AT FULL THROTTLE SEA LEVEL PRESSURE
FULL THROTTLE AIR PRESSURE
SUPER CHARGED OPERATION
FUEL FLOW RATE = 0.00074 lb/sec
FUEL FLOW RATE = 0.00061 lb/sec
FUEL FLOW RATE = 0.00056 lb/sec
SPARK ADVANCE
ENGINE DATA: SPEED 1200 r p m OPTIMUM IGNITION TIMING MARKED ON CURVES FOR EACH FUEL FLOW RATE
BRAKE MEAN EFFECTIVE PRESSURE - pounds per square inch
MANIFOLD PRESSURE - inches of Hg.
AIR MASS FLOW - pounds per second
0.0038 0.0047 0.0071 0.0075 0.0084 0.0093 0.010

Fig. 4. Output of engine (B.M.E.P.) versus air supply for several constant fuel flow rates.

signal which is used to adjust the input in a way that causes the output to approach its optimum performance level.

Optimalizing controllers offer certain advantages over regulators for the control of systems with complex performance characteristics. One advantage is that the optimalizing controller uses the controlled system itself as an instrument for determining the relationship between its output and its controlled input. Beyond the assumption that some optimum performance condition exists, no knowledge is required about either the linearity of the system or the quantitative values of the coefficients associated with the performance of the controlled system. This means that the optimalizing controller will always search out optimum performance no matter how environmental conditions or the controlled system may change, so long as some optimum condition exists. This fact distinguishes the optimalizing controller from regulator systems, which must depend on the controlled system in continuously

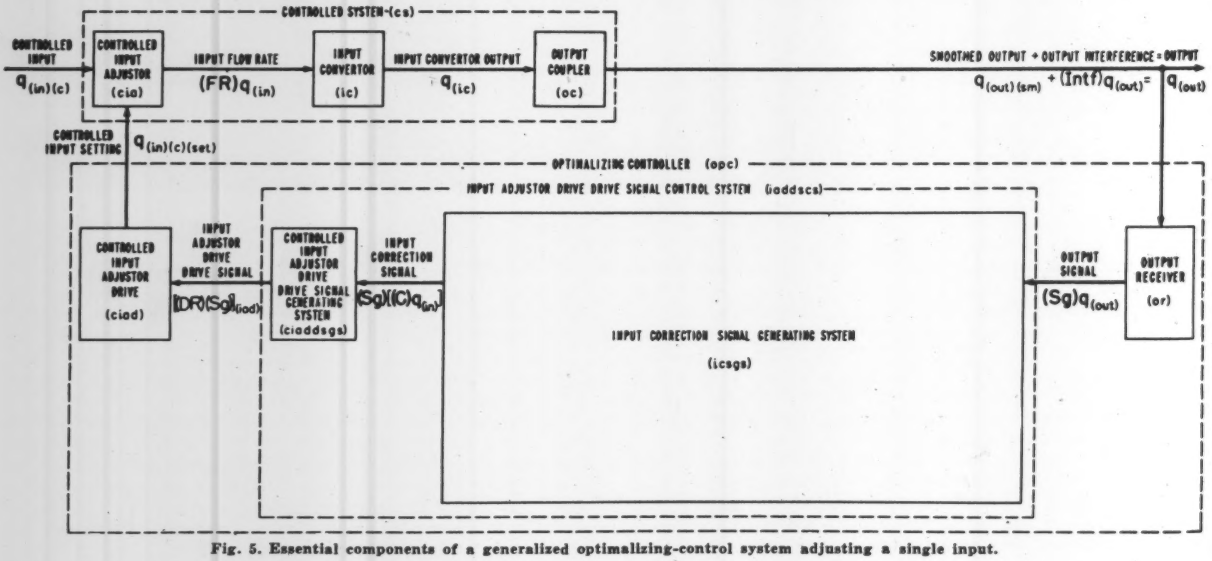
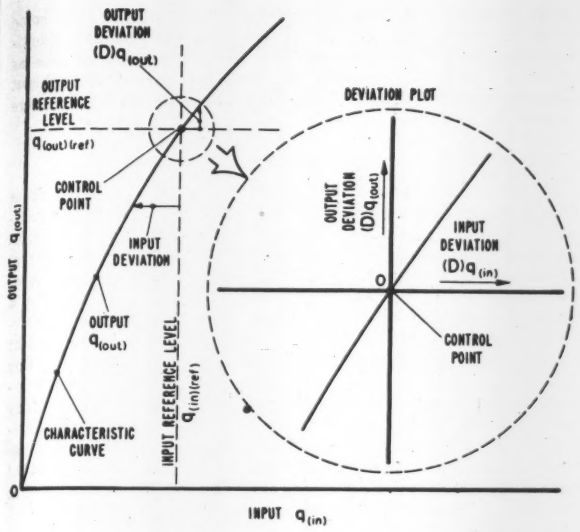

CONTROLLED SYSTEM-(cs)
CONTROLLED INPUT
CONTROLLED INPUT ADJUSTOR (cia)
INPUT FLOW RATE
INPUT CONVERTOR (ic)
INPUT CONVERTOR OUTPUT
OUTPUT COUPLER (oc)
SMOOTHED OUTPUT + OUTPUT INTERFERENCE = OUTPUT
CONTROLLED INPUT SETTING
OPTIMALIZING CONTROLLER (opc)
INPUT ADJUSTOR DRIVE DRIVE SIGNAL CONTROL SYSTEM (iaddsca)
CONTROLLED INPUT ADJUSTOR DRIVE (ciad)
INPUT ADJUSTOR DRIVE SIGNAL
CONTROLLED INPUT ADJUSTOR DRIVE DRIVE SIGNAL GENERATING SYSTEM (ciaddsgs)
INPUT CORRECTION SIGNAL
INPUT CORRECTION SIGNAL GENERATING SYSTEM (icsgs)
OUTPUT SIGNAL
OUTPUT RECEIVER (or)

Fig. 5. Essential components of a generalized optimalizing-control system adjusting a single input.



$$\text{OUTPUT DEVIATION} = \text{OUTPUT} - \text{OUTPUT REFERENCE LEVEL}$$
$$(D)q_{(out)} = q_{(out)} - q_{(out)ref}$$

$$\text{INPUT DEVIATION} = \text{INPUT} - \text{INPUT REFERENCE LEVEL}$$
$$(D)q_{(in)} = q_{(in)} - q_{(in)ref}$$

Fig. 6. Performance characteristics of a system adaptable for simple regulator-type control, showing output versus input and (insert) output deviation versus input deviation from control point.

maintaining the characteristics used in the regulator design.

Principles of Process Control

Performance Characteristics of Systems Adaptable to Regulator-type Control

Most controllers are actuated by output deviations of the controlled system. This deviation is by definition the algebraic difference between the actual level of the controlled output and some *output reference level.* The output deviation for a simple regulator acting on a system with a single essential input is illustrated in Fig. 6. The curves in this figure might represent, for example, the relationship between the speed of an internal-combustion engine as the output and the fuel-mixture flow-rate as the input, under one particular load condition while other inputs are held constant. (In practice a group of static characteristic curves is required to represent the performance of a controlled system under all load and environmental conditions.)

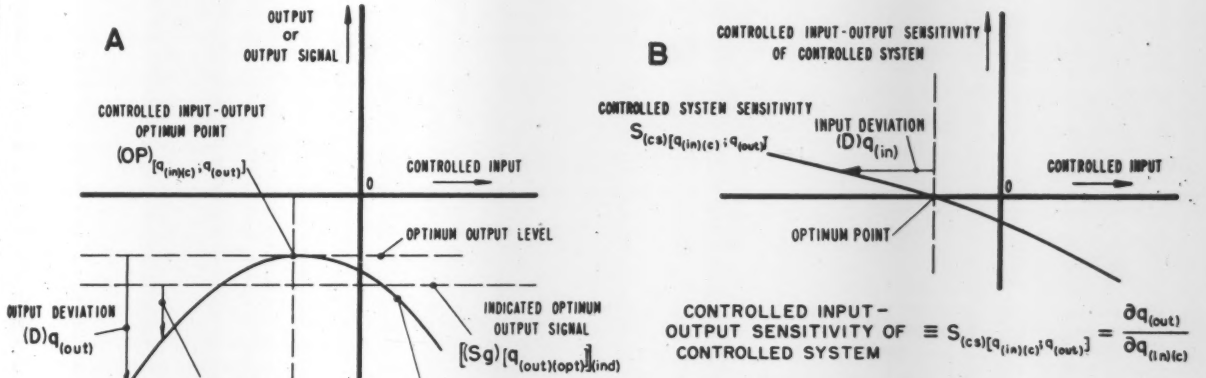
The simplest control situation exists in a regulating system which has a constant output reference level that is independent of the controlled-system operating conditions, as represented by the horizontal dotted line of Fig. 6. The actuating input for the regulator is the output deviation signal. The arrow in the figure points to an amplified section of the characteristic curve near the control point, which is a plot of output deviation versus input deviation.

If an operating system is suitable for regulating control, the characteristics must intersect the reference level at only one point, which is called the *control point.* In general, within a small range of operation near this control point it is possible to represent the input deviation by the output deviation signal—that is, the curve is linear. The control problem of a regulating system thus becomes that of adjusting the input to make the input deviation approach zero. The technique involved in this type of problem is common in feedback servomechanisms.

Performance Characteristics of Systems Adaptable to Optimalizing Control

The effective output reference level for a controlled system is not necessarily constant or independent of operation. For example, the effective output reference level for an optimalizing controller is the *optimum output level,* which is not constant but is automatically varied, depending on the location of the optimum point of the characteristic curve for the controlled system, as shown in Fig. 7a. In principle the actual controller input must be a signal representing the output deviation from the optimum output level used as a reference. In practice it is not feasible to generate a signal of this kind accurately because of the difficulty of continuously producing a signal level representing the optimum output level. However, it is possible to obtain an *indicated optimum output reference* that can be used to produce the *indicated output-deviation* signal, which in practice can be the essential input for an optimalizing controller. The definition of the indicated output-deviation signal is illustrated in Fig. 7a.

Sensitivity.—Fig. 7b shows the sensitivity of the controlled system as a function of the controlled input. This sensitivity is by definition the partial derivative of the



$$\text{CONTROLLED INPUT-OUTPUT SENSITIVITY OF CONTROLLED SYSTEM} \equiv S_{(cs)[q_{(in)(c)};q_{(out)}]} = \frac{\partial q_{(out)}}{\partial q_{(in)(c)}}$$

Note: The characteristics of a) and b) apply only to situations in which the controlled system has a single essential input, or in which all inputs except the controlled input are held constant.

Fig. 7. Typical performance characteristic of a system suitable for optimalizing control. A, performance characteristic, showing output versus controlled input; B, sensitivity characteristic, showing sensitivity versus controlled input.

output with respect to the input. It represents the slope of the characteristic curve of output versus controlled input, with all other inputs held constant. At the optimum point the slope of the characteristic curve becomes zero and the sign of the slope changes from positive to negative.

An optimalizing controller is similar in operation to a performance-regulating system in one respect—the input adjustor of the controlled system is driven to minimize the input deviation from the control point. In an optimalizing system the control point is the optimum point.

In Fig. 7b it is shown that the sensitivity of the controlled system is fairly linear with input deviation from the control point. Thus the input deviation from the optimum point can be represented by the sensitivity of the controlled system in the same way as, in Fig. 6, the output-deviation signal represents the input deviation for the performance-regulating control system. For this reason, in an optimalizing system the controlled-system sensitivity may be used in a feedback loop to adjust the controlled input according to the same principle as that described for the performance-regulating system.

Optimalizing control may be based not only on the sensitivity of the controlled system, but also on the indicated output-deviation signal, which is defined in Fig. 7a. In principle, this deviation signal furnishes information as to the magnitude of the input deviation. The sign (polarity) of the input deviation may be obtained by a trial-and-error procedure incorporated in the operation of the controller, so that complete information of the input deviation can be obtained from the indicated output deviation.

Signals representing the output from a controlled system usually are easy to obtain. This means that the principal problem in the design of a controller using output deviation as its essential input is to generate an *indicated optimum output signal* which is a close representation of the actual optimum output level. When controlled-system sensitivity signals are used for control purposes, the reference level is zero and thus is simple to realize in practice. On the other hand, the problem of generating signals that represent the sensitivity of a controlled system is not simple. The several possible approaches to this problem lead to various controller types.

Types of Optimalizing Controllers

There are two classes of optimalizing controllers, depending on the type of input signal that is used for operation. These classes, with sub-classes, are as follows:

1. *Sensitivity-operated controllers*
   (a) Sensitivity-signal input controllers
   (b) Continuous-test-signal controllers
   (c) Output-sampling controllers
2. *Peak-holding controllers*

All optimalizing controllers of the first type act by using the controlled system itself to generate a signal which represents its sensitivity, and then using this signal as the essential controller input signal. Optimalizing controllers of the second type operate by continuously searching for an *indicated optimum-output-level signal*, which is used in the generation of the *indicated output-deviation signal.*

Optimalizing-Control Test-Functions

Optimalizing control depends on a suitable indication of either the sensitivity or the optimum output level of the controlled system. To generate a sensitivity signal, or to establish an indicated optimum level, data from more than one operating point are necessary. In practice, some test variation of a suitable function with time is applied to the controlled input. The test input variation, or forcing function, produces a corresponding output variation. By proper correlation of the test input variation with the corresponding output variation, it is sometimes possible to determine the input-output sensitivity or the indicated optimum output level.

In the vicinity of the optimum level, the input test variation produces an output variation which usually remains below the optimum output level within an output *hunting zone*. This output hunting action is responsible for some output hunting loss and represents the cost of using optimalizing control. It is desirable to keep the hunting zone as small as possible by using the smallest practicable input test variations. However, the test variation must be large enough to be useful.

Random-interference Components

In order to measure the output variation resulting from the input test variation, it is necessary for this output variation to have frequency components that can be distinguished from output variations caused by random interference.* The relative amplitudes of the frequency components making up the output interference spectrum for a typical operating system are given in Fig. 8. *Drift interference* is associated with slow changes in the environment or internal conditions of the operating system and for this reason are made up of low frequencies. *High-frequency interference* occurs above some lower limit. Satisfactory optimalizing control depends on the existence of some frequency range substantially free from strong interference components. The control problem is to design equipment based on test functions with frequency components that

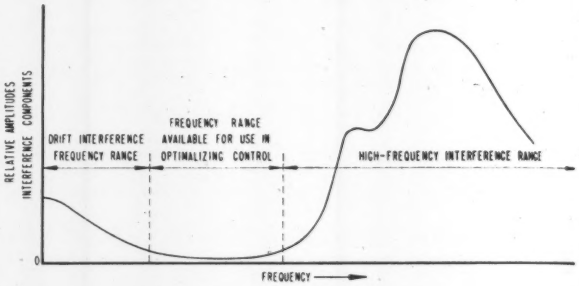


Fig. 8. Relative amplitudes of interference components of a typical operating system as function of frequency.

may be recognized in the presence of normal output interference without causing unacceptably large hunting. In general, the test function must be made up of input variations that are fast enough to be distinguishable from drift interference, and at the same time slow enough to prevent confusion with high-frequency interference effects. The practical minimum limit for the output hunting zone is determined by the success achieved in meeting these conditions.

Sensitivity-Signal Input Controller

In principle, the sensitivity of a controlled system can be obtained by introducing a suitable input variation to the controlled system, and then dividing the rate of change of the output signal by the rate of change of the input signal. The process of taking the ratio between the output rate signal and the input rate signal eliminates the time element from the function; the resulting quotient is a signal representing the sensitivity of the controlled system. For simplicity in illustration, an input variation with a constant rate which can be reversed in direction is considered first. This type signal sometimes is called a triangular sawtooth signal.

System With Triangular Test Function

Fig. 9 gives a typical control diagram for the direct sensitivity-signal optimalizing controller. The curves in Fig. 9b and 9d are the characteristic curves for output and sensitivity, respectively, both plotted against input. The curves of plots (a), (e), and (c) are the controlled input, the output rate signal, and the output signal, respectively, all plotted as functions of time. The controlled-input variation, or test function, is generated by a constant-speed change of the input, with reversal at points determined by operation

* This problem is essentially the same as the signal-to-noise problem in all low-level circuits, systems, etc.—ed.

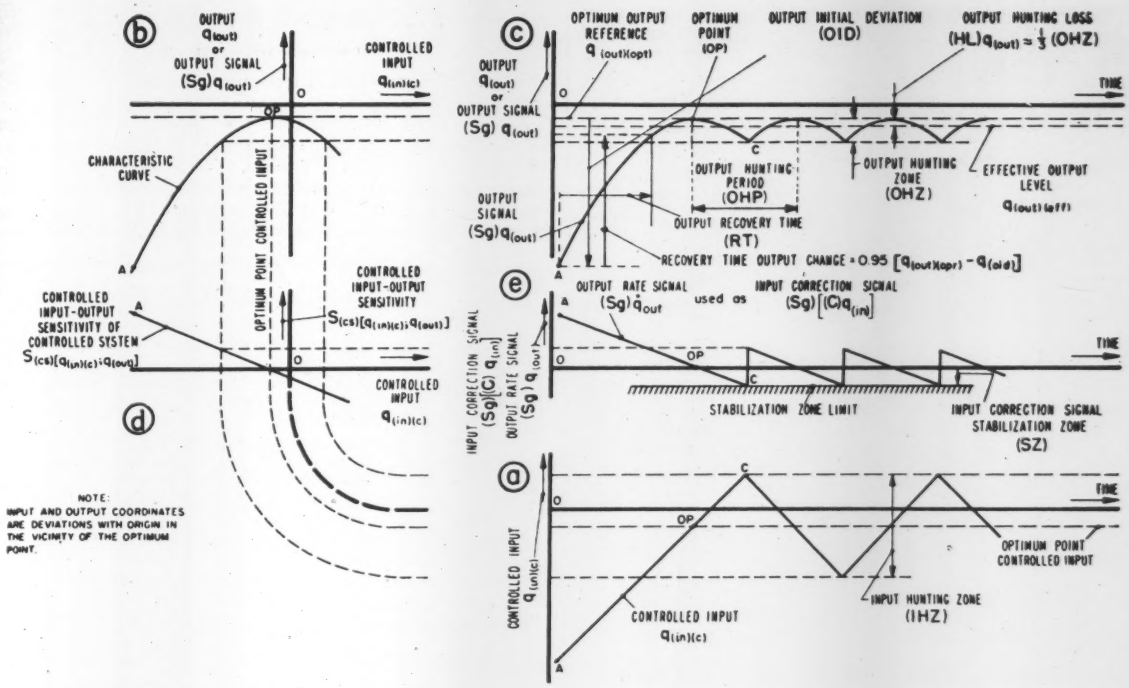


Fig. 9. Typical performance characteristics of an operating system controlled by an optimalizing controller of the sensitivity-signal type which uses a triangular forcing function. A, triangular-type test signal; B, characteristic curve of system; C, output variations caused by input variations; D, sensitivity characteristic of system; E, rate of output variation.

of the controller. (Note that the use of constant rate is a special case; variable rates may be used where required.)

The sensitivity signal of the controlled system is equivalent to the output rate signal produced by the *correction-signal-generating system* of Fig. 5. When this output rate signal becomes larger than a *stabilization-zone limit*, the system is designed so that the controlled-input adjustor drive of Fig. 5 causes the controlled input to change direction. This action is illustrated in Fig. 9a. When the output signal passes the optimum point and starts to decrease, the output rate signal becomes negative and passes through the stabilization zone. At the lower limit of this zone the direction of the test signal is reversed. The size of the stabilization zone is chosen so that the controller does not respond to random interference components in the output signal.

Hunting Zone

Figure 9 shows that the operating cycle continues indefinitely. The automatically-controlled triangular test signals produce a repeating series of concave output signals. The *output hunting zone* is by definition the difference between the highest and lowest output levels caused by action of the controller. The *effective output* (the constant output level that would be required to produce the same average output as that actually produced by the controlled system with the controller operating) is less than the *optimum* output level because of the hunting zone. These quantities are illustrated in Fig. 9c. This diagram also shows the *output hunting loss*, which is the difference between the optimum output and the effective output.

In many practical situations the input-output characteristic near the optimum point can be approximated by a parabolic curve. When this approximation is valid, it can be shown that the output hunting loss is one-third of the hunting zone. Although the one-third factor may not apply accurately in all cases, it is reasonable to assume that the output hunting loss will always be some fraction of the output hunting zone. This means that one of the prime objectives in optimalizing-controller design is to reduce the output hunting zone to the lowest feasible magnitude.

Output Recovery Time

Fig. 9c shows another performance characteristic of the optimalizing system— the *output recovery time*. The output recovery time is defined as the time required for the controlled system to pass through 95 percent of the required output correction from an arbitrary initial setting which is different from the final effective output level. The choice of 95 percent, instead of the complete initial correction, for the definition of recovery time simplifies measurements by allowing the terminal instant to be taken when the rate of change of output is still large enough for accurate observations. Furthermore, if the controlled system follows an approximately exponential law, the recovery time is equal to three *characteristic times** of the exponential.

In practice, controlled systems are often subjected to sudden changes in operating conditions. Short recovery times are necessary to minimize output losses during the periods following changes, and to insure stable operation.

The direct sensitivity optimalizing controller described in Figs. 5 and 9 represents the simplest design for an optimalizing controller. For this reason it has been used to illustrate the concepts associated with controller performance and to establish the requirements for operation, although superior results may be achieved with other arrangements. The primary difficulty in a sensitivity optimalizing controller is that the control signal is produced by differentiation of an output signal. As differentiation increases the effects of high-frequency interference components, relatively large stabilization zones must be used. If the controlled system has small high-frequency interference components, direct sensitivity control may operate properly. On the other hand, the interference components present in the output of a piston-type internal-combustion engine are so large that the necessary stabilization zone does not permit close output control.

* By definition, characteristic time is identical with the conventional time-constant for a simple resistance-capacity network. It is the constant $1/k$ in the expression e^{-kt}, or the time for an exponential curve to pass through 63.2 percent of its total amplitude.

Continued next month

EXACT WEIGHT Shadograph in a small animal weighing operation for laboratory experimental purposes.

Precision Equipment for Small Animal Weighing . . .

Weigh a mouse? What an unusual request but more unusual an order for an EXACT WEIGHT Scale a little later. But that has been many years ago now. Since then thousands upon thousands of mice, rats, guinea pigs, and rabbits in laboratories from coast to coast have been handled on many models of these well-known industrial precision scales. In the past our mechanical models were used . . . fitted to the operation desired . . . cutting weighing time in volume small animal experiments to a fraction of the time required with ordinary even balance scales. Today these types of experiments in laboratories as well as numerous other laboratory proceedure are handled by EXACT WEIGHT Shadograph . . . a unit that is electrically operated . . . uses a light ray instead of mechanical indication . . . has tremendously wide range in sensitivity, accuracy and capacity as well as high speed operation not present in most other weighing units for laboratory work.

"Sales and Service from coast to coast"

Write for details for your particular task.

EXACT WEIGHT SCALES

Industrial Precision

THE EXACT WEIGHT SCALE COMPANY

951 West Fifth Avenue, Columbus 8, Ohio

2920 Bloor St., W. Toronto 18, Canada

INSTRUMENT ELECTRONICS

Continued from page 69

emitter. Mercury-pool tubes use a pool of mercury to supply electrons.

An arc must be struck at the surface of the mercury before the mercury emits electrons. This arc is struck by an electrode, called an *igniter*, which usually is made of silicon carbide and projects into the pool of mercury, as shown in Fig. 6-7. The igniter is connected to an auxiliary tube that supplies the starting current of about one ampere to the igniter.

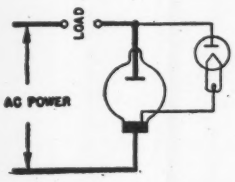


Fig. 6-7. Mercury-pool tube.

At the instant that an arc forms between igniter and mercury pool, a spot is formed on the pool and the mercury vapor in the tube ionizes. The spot, which acts as a cathode, can emit a large current—10,000 amperes can be drawn from a mercury spot only 1 inch in diameter.

Mercury-pool tubes have the advantage of requiring no heated cathode, as does a thyratron. However, the power required by the igniter is much larger than the power required by the thyratron grid. Hence mercury-pool tubes are used mainly for high-power applications requiring hundreds or thousands of amperes. In such large

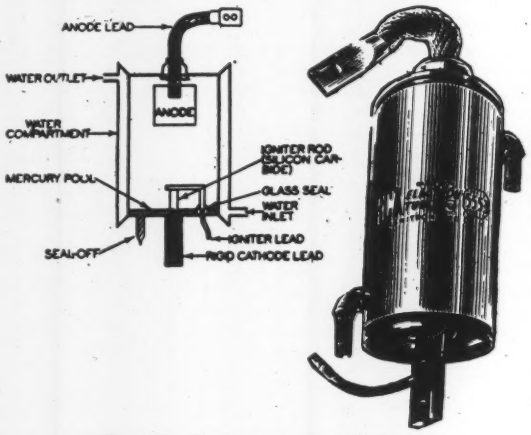


Fig. 6-8. Construction of an ignitron.

sizes, the mercury-pool "tube" is a steel tank, 10 or 15 feet in diameter, with many anodes and an integral vacuum-pumping system.

Ignitrons

Modern mercury-pool tubes with improved arc-starting rods are known as ignitrons. Fig. 6-8 shows the construction of a typical ignitron. Cooling water flows between the tube and the outer shell.

The ignitron is used widely in resistance welding. It can supply a 50,000-ampere current for several cycles for a spot weld.

COMPARISONS

The ignitron, thyratron, and phanotron are all rectifiers—that is, when a.c. is applied to the tube and a load in series, only pulsating d.c. flows through the circuit. The ignitron can carry a heavier current than the thyratron or phanotron. The phanotron has no control grid (like the thyratron) or igniter (like the ignitron). Hence, unlike the latter two, the phanotron can not be used for smooth control of current.

TEST ITEMS FOR—VI. GAS-FILLED TUBES

6-1. A gas-filled tube differs from a vacuum tube in that the former
(a) is not evacuated
(b) is available as a diode, triode, or tetrode
(c) can carry large plate current
(d) has high plate resistance

6-2. A tube with high efficiency has a
(a) low plate resistance
(b) low plate current
(c) high vacuum
(d) high pressure

6-3. The grid in a gas-filled tube differs from that in a vacuum tube in that it controls the plate current
(a) by being near the hot cathode
(b) at all times
(c) only until the gas ionizes
(d) only after the gas ionizes

6-4. Gas molecules that lose electrons are called
(a) negative ions
(b) positive ions
(c) saturation current
(d) space charge

6-5. Saturation current can flow through a gas tube as soon as the gas ionizes because the
(a) gas ions neutralize the space charge.
(b) gas ions move to the plate
(c) tube is operated with high negative bias
(d) tube is operated with high positive plate potential

6-6. A gas tube has an ionization potential below which no plate current can flow because the
(a) positive ions move toward the cathode
(b) gas is a good conductor
(c) electrons must reach the plate
(d) electrons must reach a high velocity

6-7. In a gas tube, the plate potential at which the ionized gas deionizes is known as the
(a) firing potential
(b) striking potential
(c) extinction potential
(d) inverse voltage rating

6-8. The inverse voltage rating of a gas tube differs from that of a vacuum tube in that the former
(a) is the maximum voltage by which the plate can safely be more negative than the cathode
(b) decreases with the frequency of the applied signal
(c) can damage the tube if exceeded
(d) applies to diodes only

6-9. The ionization and deionization times of gas tubes are in the order of
(a) microseconds
(b) milliseconds
(c) seconds
(d) minutes

6-10. A neon glow lamp can conduct equally well in both directions because both electrodes are
(a) heated to the same temperature
(b) both the same size and construction
(c) made in the form of grids
(d) voltage regulators

6-11. The glow that occurs in gas tubes is caused by
(a) electrons striking the plate
(b) electrons striking the grid
(c) ejection of electrons from gas molecules
(d) recombination of positive ions and electrons

6-12. A glow tube can be used as a voltage regulator because the
(a) extinction and ionization potentials are the same
(b) voltage drop across the tube is independent of the current
(c) tube current is independent of voltage applied across the tube
(d) voltage drop is independent of the type of gas in the tube

6-13. The hot-cathode gas-filled diode is called a
(a) phanotron
(b) rectifier
(c) gas tube
(d) all the above

6-14. When using mercury rectifier tubes, it is important that
(a) the heater potential be applied before the plate potential
(b) the grid potential be applied before the plate potential
(c) the current be kept at a low value at all times
(d) all the above

6-15. A thyratron is a
(a) hot-cathode gas diode
(b) cold-cathode gas diode
(c) grid-controlled gas tube
(d) phanotron

6-16. The plate current through a thyratron can be stopped by
(a) reducing the grid potential to cut-off
(b) reducing the plate potential
(c) applying extinction potential to the grid
(d) all the above

6-17. A thyratron with an a-c. plate voltage can be made to conduct for any portion of the
(a) positive half cycles of plate voltage
(b) negative half cycles of plate voltage
(c) entire a-c. plate cycle
(d) ionization time

6-18. When a thyratron is controlled by an a-c. signal applied to the grid, the average output current is controlled by varying the
(a) temperature of the cathode
(b) amplitude of the plate voltage
(c) instantaneous plate current
(d) phase of the grid signal

6-19. The cathode in a mercury-pool tube is the
(a) oxide-coated emitter
(b) igniter
(c) mercury spot
(d) ionized gas

6-20. A disadvantage of mercury-pool tubes over thyratrons is that the former
(a) requires no heated cathode
(b) can supply larger currents
(c) requires igniter power
(d) all the above

6-21. The function of the igniter in a mercury-pool tube is to
(a) initiate the mercury spot
(b) produce the vacuum
(c) deionize the gas
(d) supply current to the grid

6-22. Which of the following gas tubes has no provision for controlling the firing point?
(a) Ignitron
(b) Thyratron
(c) Phanotron
(d) All the above

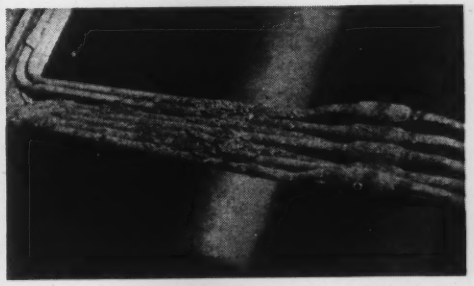
Dekoron®
PLASTIC ARMORED METAL

cuts instrument tubing costs

2 ways...

FIRST—Dekoron tubing costs less than expensive alloy instrument tubing . . . conserves hard-to-get critical materials, too.

SECOND—Dekoron outlasts every other type tubing which Samuel Moore & Company has studied...has outlasted every kind of tubing which customers have reported trying.



Dekoron tubing still in good condition after 2½ years' exposure to deposits high in hydrochloric acid. Copper was destroyed in 18 months.

Dekoron tubing is not metal only, not plastic only—it combines the advantages of both materials. Dekoron has a thick, corrosion-resistant coating of polyethylene or vinyl plastic tightly extruded over steel tubing. Or for special installations, copper or aluminum can be used.

Lengths of Dekoron tubing are joined with standard fittings covered with plastic tape to make the complete installation impervious to corrosive fumes from acids and alkalies, moisture, salt air, oils and grease. No expensive painting or other maintenance is required.

If you have a corrosion problem, write for data sheet "Dekoron—a better kind of corrosion-resistant instrument tubing." Tells how Samuel Moore & Company coats customers' tubing and lowers costs. A-4946

Dekoron tubing

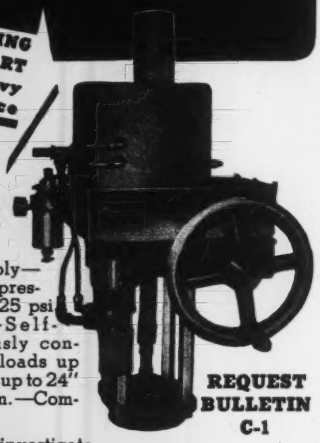
SAMUEL MOORE & COMPANY
Dekoron Tubing Division
MANTUA, OHIO

NEW! GEAR-DRIVEN PNEUMATIC OPERATOR FOR THROTTLING CONTROL SERVICE

Rotomotor

PNEUMATIC POWER POSITIONING OPERATOR

ACCURATE POSITIONING TO WITHIN 1/500th PART of STEM TRAVEL on Heavy Duty Throttling Service



A wholly new and different valve operator employing a reversible pneumatic motor and a precision gear driven screw stem, with these AMAZING advantages:

Operates on 100 psi supply—Sensitivity to instrument pressure changes as small as .025 psi—Perfect stability—Self-locking stem—Continuously connected handwheel—Stem loads up to 40,000 lbs.—Stem travels up to 24" Stem speeds up to 36" p.m.—Compact design.

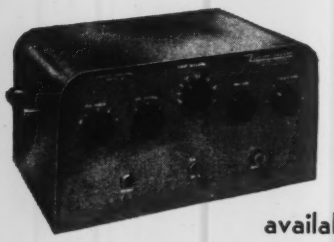
REQUEST BULLETIN C-1

So different, you will want to investigate its possibilities immediately.

Conoflow Controls

CONOFLOW CORPORATION

Lowest Noise Level
Highest Zero Stability



of any Commercially-built D-C Amplifier available today make the

LISTON-BECKER Model 14

Breaker-type D-C AMPLIFIER

an essential tool for the most exacting determinations in such diverse fields as chemotherapy, optical pyrometry, physiology, precision calorimetry, and scores of other applications requiring the highest accuracy. Bulletin on Request.

LISTON-BECKER Dept N

Instrument Co., Inc., Stamford, Conn.

REFINERY CONTROL PROBLEMS

Continued from page 71

The mercury manometer was replaced by a "Foxboro D/P" cell. The "D/P" cell was mounted as close as possible to the orifice flange, supported only by its piping. After steam tracing the installation we found the measurement problem was whipped.

Controlling—the second half of the problem—was solved by designing and using a piston-type valve. The valve, as shown in Fig. 4, consists of a conventional control-valve

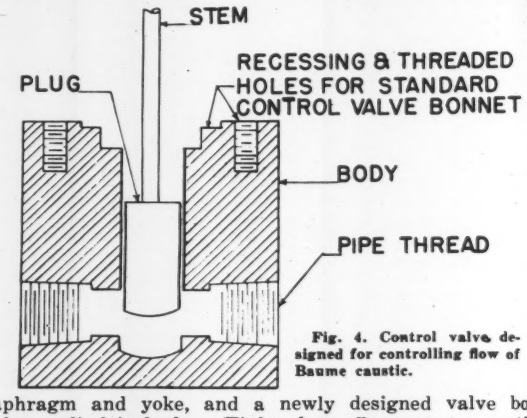


Fig. 4. Control valve designed for controlling flow of Baume caustic.

diaphragm and yoke, and a newly designed valve body with a cylindrical plug. Tight shut off was not essential. A somewhat balanced plug was obtained by cutting a slot on the downstream side of the plug. This equalized the pressures on the top and bottom of the plug. Our instrument men refer to this valve as the "bone crusher."

Dual-range Mercury-manometer Flowmeters

The mercury-differential-type flowmeter in its standard simple form (with cylindrical mercury chambers and square-root flow scale) is limited in usefulness where there are wide changes in rate of flow. The rangeability, or ratio, for reasonably accurate flow readings is about 3 to 1.

There are innumerable flow measurement and control applications where the maximum rate may be six or more times as great as the minimum flow. A few examples are: Seasonal changes in heating steam load; variations in feed and product rates on a refining process caused by fluctuations in supply, demand, and compositions; and variations in solvent feed ratio requirements with changes in types of charging stock.

Numerous flowmeter designs and arrangements are available for improving the rangeability of the conventional square-root flow scale. Dual-range meters of a somewhat novel design (Fig. 5) have been used successfully on several applications in our Lake Charles refinery. The design may be found useful in other plants.

Fig. 5 shows the arrangement of the mercury chambers,

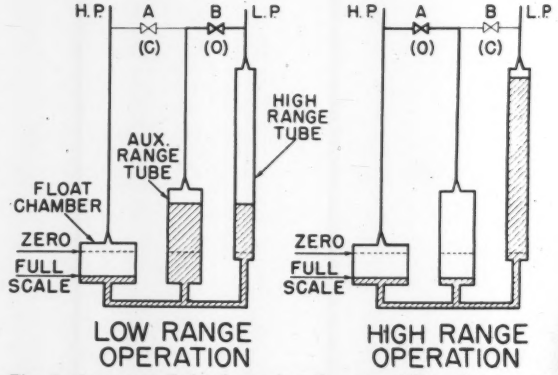


Fig. 5. Arrangement for increasing the rangeability of a mercury manometer.

CUT COSTS on MOISTURE CONTROL

KEMP DYNAMIC DRYERS DRY INSTRUMENT AIR TO LOW DEW POINTS FOR AS LITTLE AS ¼c PER MCF.

Kemp Dryers save industry thousands of dollars a year—because they protect costly instruments from damage due to moisture in the air or air source. Operation is guaranteed to your specifications, and standard models are available for any instrument air drying operation—whether it's large or small. **Send For Information.** Kemp has a Dynamic Dryer designed for every application. Find out how Kemp can solve your problem. Write today—no obligation.

KEMP OF BALTIMORE

DYNAMIC DRYERS

Write for Bulletin D-27 for technical information. C. M. KEMP MFG. COMPANY, 405 E. Oliver Street, Baltimore 2, Maryland.

CARBURETORS • BURNERS • FIRE CHECKS • ATMOSPHERE GENERATORS • ADSORPTIVE DRYERS • METAL MELTING UNITS SINGEING EQUIPMENT • SPECIAL EQUIPMENT

2 NEW ELECTRIC PRODUCTIMETERS

"CS" and "Y" ELECTRIC PRODUCTIMETERS The answer to all electric counting requirements

Two Companion Counters . . . Two Sizes . . . Hi-Speed . . . Accurate . . . Long Life . . . Totally Enclosed

Speeds of 1000 counts per minute. Both counters give maximum readability. Design fits all mounting conditions . . . panel mounting or base mounting. Hardened steel working parts for long life and dependability.

New type case for compactness, rigidity, and protection against dust and moisture conditions. Operate accurately over wide current fluctuations.

Write for "New Electrics" Bulletin

DURANT MANUFACTURING CO.

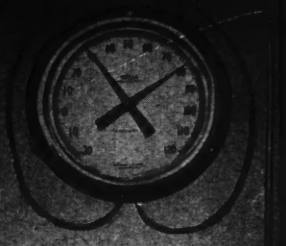
1914 N. Buffum St. Milwaukee 1, Wis.

114 Orange St. Providence 3, R. I.

Representatives in Principal Cities

PRODUCTIMETERS SINCE 1879 *Count Everything*

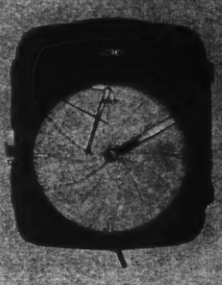
FOR CONSTANT DEPENDABILITY *Install* MOELLER DIALS and RECORDERS

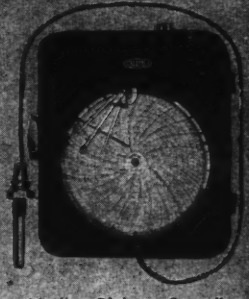


Remote Reading Type. Mercury actuated with separable socket connection. Back connection or flush mounting.

Duplex, mercury actuated, plain bulb type indicates temperatures at two separate points.

TEMPERATURE RECORDING TYPE





Single and multiple pen, Remote Reading types in rectangular or round cases.

Moeller Dial or Recording Thermometers can be furnished with electrical contacts.

FOUR GENERATIONS have depended upon the accuracy of Moeller instruments.

FOUR GENERATIONS have relied upon the unfailing precision of all Moeller products.

***Eighty* years of such confidence in proven performance establishes the name Moeller as a guarantee of perfection in the engineering and manufacture of temperature indicating and recording instruments.**

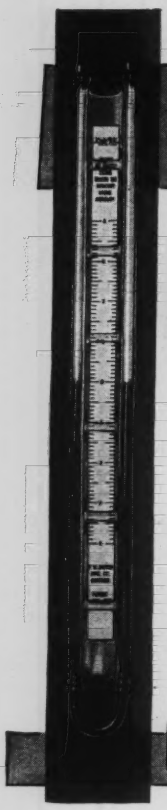
Send for catalogs and literature on

INDUSTRIAL LABORATORY AND RECORDING THERMOMETERS THERMOSTATS • HYGROMETERS HYDROMETERS • PSYCHROMETERS AND MARINE SPECIALTIES

MOELLER INSTRUMENT COMPANY

132nd ST. and 89th AVE. • RICHMOND HILL 18, N. Y.

Representatives in Principal Cities



Really New!

A FLEXIBLE MANOMETER

Just Roll It Up and Tuck It Away

No more cumbersome 2', 3', or 4' manometers to cart around. This new flexible Dwyer Manometer will fit into your pocket or the corner of your service kit. This revolutionary instrument is fabricated of tough, vinyl plastic that will serve for years. The plastic scale is firmly supported between the tubes. Standard ranges from 8 in. to 6 ft. of water or mercury. It is highly accurate, easy to read and convenient. Nothing like it for field work. Write for complete information.

F. W. Dwyer Mfg. Co.

305 South Western Ave., Chicago 12, Ill.

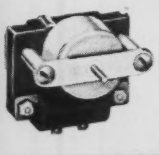
Quiet! Forty million Telechron® motors at work!

TODAY, in instruments and other devices, more than forty million Telechron synchronous motors are at work...quietly serving the nation's industries, laboratories and homes wherever accuracy, dependability and long life are vital.

As accurate as current itself, the Telechron motor's light rotor is perfectly synchronized with AC impulses. It responds immediately and reaches full speed in a fraction of a second.

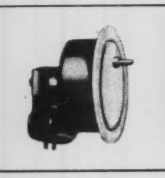
It's a fact that the rotor shaft bearing of a Telechron motor has never worn out, as long as lubrication is constantly maintained.

For complete specifications on the full line of Telechron motors, write for booklet IS-120. Telechron Dept., General Electric Company, 61 Homer Avenue, Ashland, Massachusetts.



Type B3 Motor—*For medium-duty switching, controlling and recording-controlling, such as time switches, business machines, and recording instruments.*

Type C5 Motor—*For heavy-duty timing, switching and controlling, such as traffic controls, airfield landing lights, tower clocks and instrumentation.*



Telechron

U-tubes, and valve manifolds, and also the mercury levels under various conditions. The standard float chamber, shown at the left, is on the high-pressure, or upstream, side of the orifice. The auxiliary range tube is shown in the center; the so-called high-range tube is shown at the right. In operation on low-range service, valve "A" is closed and valve "B" is opened to place the two range tubes in parallel, both on the low-pressure, or downstream, side of the orifice. The mercury levels rise simultaneously in these two tubes as the differential pressure increases. The two range tubes are the equivalent of one large-diameter range tube.

For high-range service, valve "B" is closed and valve "A" is opened to place the auxiliary tube in parallel with the float chamber. When the differential pressure increases, the mercury levels fall simultaneously in the float and auxiliary chambers, and rise only in the right-hand, or high-range, tube. This is the equivalent of a large-diameter float chamber and a relatively small-diameter range tube.

With this design it is possible to change from low to high range or vice versa by manipulating valves "A" and "B," without zeroing the meter. On a sealed meter, however, it is desirable first to equalize and zero the meter in the conventional manner. Otherwise some loss of sealing liquid and unbalancing of the seals would take place after repeated range-changing.

Dual-range flowmeters are now available from several manufacturers, usually in flow range ratios of 2 to 1. Flow range ratios of 3 to 1 would be more desirable.

For those who find a need to build their own dual-range meters, the diameters of the auxiliary and high-range chambers can be calculated easily from formulas which have been derived from simultaneous algebraic equations. The known conditions to be substituted in the formulas are (1) the desired high and low differential ranges expressed in inches of water dry calibration, (2) the float chamber diameter, and (3) the float travel for full-scale deflection.

A Process Control Problem: Surging of Sidestream Level Controllers

A condition which demanded attention existed in our sidestream strippers at the Crude Topping Units and Fluid Catalyst Cracking Units.

The level-measuring devices were displacement-type "leveltrols." At the Crude Topping Units the level instruments were controlling the valves directly, with the controlled air showing percentage of valve opening on indicating gages in the control rooms. At some Fluid Catalyst Units the level instrument transmitted to instrument-type recording controllers.

The condition demanding attention was an erratic cycling of the level instruments and control valves. The pulsations varied in time from several per minute to one in three minutes, and in intensity from 1-psi. to 5-psi. change in the controlled air pressure (Fig. 6). This condition was determined by connecting a pressure recorder into the output air lines between the level controllers and the valves.

An experiment was conducted to see if this condition

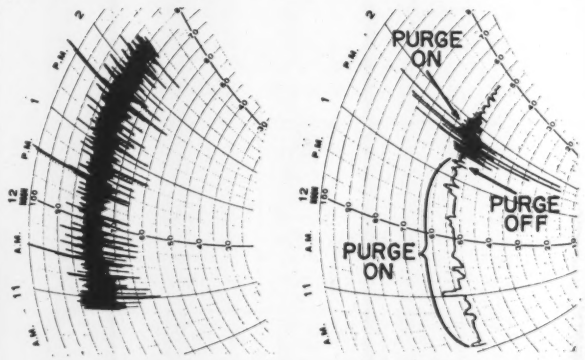
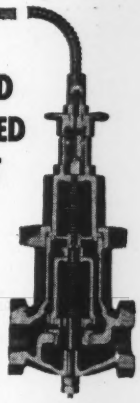


Fig. 6. Stripper-level records. Left, without purge; right, with and without purge.

SELF -CONTAINED -CONTROLLED -SUFFICIENT -RELIANT



Stacon Temperature Regulator*

The patented Farris Stacon Temperature Regulator is easily the most independent regulator available today. It's unique. It stands alone. It's trustworthy. It needs no watching. It's perfect for the man who wants no cause for worry . . . who wants to relax in the sure knowledge that his temperatures are constant.

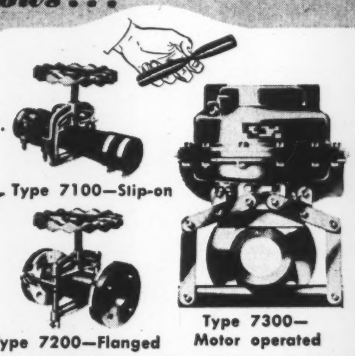
Here's why Stacon stands alone in the field. It has no packing glands to leak or bind . . . the stem moves freely. The liquid in the bulb flashes to vapor in the power bellows, assuring hairtrigger response to move the disc. It operates with unbelievable accuracy—to within plus or minus 1 degree—and it operates with that accuracy under *all* conditions. Stacon provides air-operated accuracy at low, self-operated cost.

Get the details on the one truly outstanding temperature regulator—Stacon. Send for Bulletin 50-1000 to get all the details.

*Patented and Patents Pending

Farris Stacon Corporation
536 COMMERCIAL AVE. PALISADES PARK, N. J.

if it Flows . . .



Type 7100—Slip-on

Type 7200—Flanged

Type 7300—Motor operated

Acids
Asbestos
Brines
Chips
Paper Stock
Slurries
Wood Stock
Non-Metallic Minerals

Flex-Valve it

FLEX-VALVE is the ideal choice for handling such materials as those listed—either dry or in suspension—at temperatures up to 210 deg.

Resists both abrasion and corrosion; eliminates clogging, plugging, building up; absorbs vibration and misalignment.

Open—it's as free of obstruction as the pipe itself. Closed—it's bubble-tight and it closes tight on all of these materials.

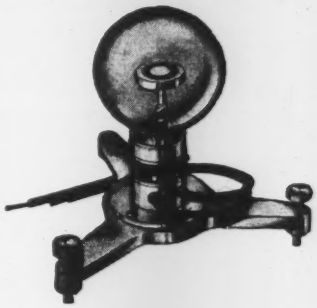
Available in either hand or air operated types in sizes from ½ to 12 in.

Users have found FLEX-VALVE to be the low-cost solution to tough valving problems. If your present valves aren't 100% effective, take a look at this one. Catalog 455 gives details.

Flexible Valve Corporation
336 COMMERCIAL AVE. • PALISADES PARK, N. J.

EPLAB

PYRHELIOMETER
For the Measurement of SOLAR RADIATION



Eppley Pyrheliometers are used for solar radiation measurements at ninety-eight weather stations in the continental United States, Canada, Alaska, Greenland, Iceland, Caribbean Sea, and the Pacific Ocean. Sixty-two of these stations are under the direction of the United States Weather Bureau.

The Eppley Pyrheliometer was adopted as standard equipment by the Weather Bureau after considerable experimentation. It was found to be the best instrument so far tested by the Bureau.

Used in conjunction with a suitable recorder, the Eppley Pyrheliometer will provide an accurate and reliable record of total solar and sky radiation on a horizontal surface.

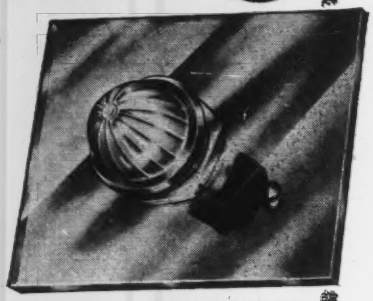
Bulletin No. 2 On Request

THE EPPLEY LABORATORY, INC.
Scientific Instruments
Newport, Rhode Island, U.S.A.

FOR YOUR PANEL DIALCO

A NOVEL and UNIQUE CIRCUIT INDICATOR

DESIGNED FOR NE-51 NEON LAMP
For 110 or 220 volt circuits
The required resistor is an integral part of this assembly —"built-in."
RUGGED DEPENDABLE LOW IN COST



PATENTED: No. 2,421,321; Cat. No. 521308-997

WILL *YOU* TRY A SAMPLE?

Write on your company letterhead. We will act at once. *No charge, of course.*

SEND FOR THE 192 PAGE HANDBOOK OF PILOT LIGHTS

Among our *thousands of Pilot Light Assemblies* there is one which will fit *your special conditions.* Many are especially made and approved for *military* use. We pride ourselves on prompt deliveries—*any quantity.*

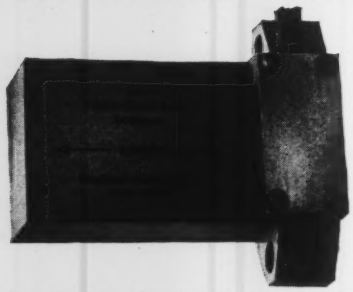
ASK FOR OUR APPLICATION ENGINEERING SERVICE

Foremost Manufacturer of Pilot Lights

The DIAL LIGHT COMPANY of AMERICA

900 BROADWAY, NEW YORK 3, N. Y. SPRING 7-1300

STATHAM LINEAR ACCELEROMETERS



The transducer in all Statham Linear Accelerometer models is an unbonded resistance wire element. The dual role of strain sensitive resistance wire—as the spring support for the seismic mass—and as the transducer—accounts for the high natural frequency not usually attained in other instruments.

The internal electrical network, a complete Wheatstone bridge, permits simple external circuit arrangements. A broad selection of bridge resistance values is provided to meet the requirements of indicating, recording, and telemetering systems.

The Model A5A illustrated is now being manufactured in an extended series of ranges from ± 8g to ± 1000g full scale. This and other models, including the F Subminiature (weighing 26 grams), are finding increasing service in the measurement of static and dynamic acceleration.

Bulletin No. 4.0 includes comprehensive data on all standard models. Inquiries concerning application problems may be directed to our engineering staff.

STATHAM LABORATORIES

SCIENTIFIC INSTRUMENTS

12401 W. Olympic Blvd. Los Angeles 64, Calif.

could be corrected. A natural-gas purge line was connected to the top of the float cage. Gas was pressured through a restriction orifice into the vapor space of the float cage. After fifteen or twenty minutes, the surging stopped, as shown in Fig. 6.

It was determined that steam was condensing in the top of the float cage. The condensed drops of liquid were falling to the lower portion of the float cage and hitting the hot oil. They would flash vaporize, causing a reaction similar to a miniature explosion, raising the pressure in the upper section of the float cage and thus causing the oil to flow back into the stripper through the lower float connection. The instrument was giving the true level within the float cage, but this level did not correspond with the level in the stripper.

Introducing the gas purge prevented the steam and light-oil vapors from entering the float cage and thereby eliminated the trouble. Two other methods of combating this problem have been used successfully—namely, steam jacketing of the float cage, and hot-oil purge of the float cage.

Removable Thermowells and Protective Guards

The feed lines to the reactor of a fluid catalytic cracking unit contain oil vapors, steam, and catalyst flowing at a velocity of approximately 60 feet per second. As the size of catalyst particles ranges from 0 to 80 microns, maintaining thermocouple cells in these lines is a serious problem. A bare thermocouple well without a guard lasts only 3 to 4 weeks. These thermocouples are the primary elements of the two temperature controllers by which the cracking reaction is controlled at about 900 deg. F. The controllers position 30-in. slide control valves which control the flow of 1100-deg. regenerated catalyst from the regenerator to the feed lines and thus to the reactor.

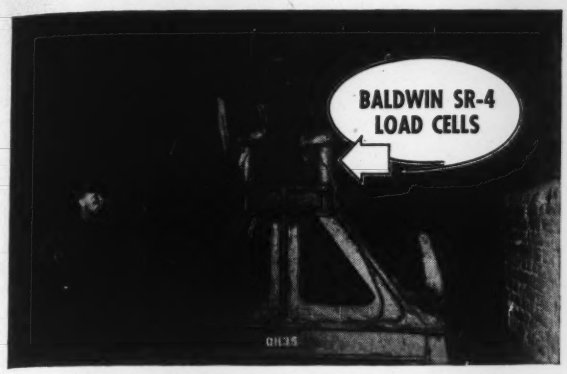
In crude-oil refining, the operating units, until recent years, were off stream frequently for clean-out. Thus the replacing of thermocouple wells and guards was simply a matter of routine maintenance. At present, however, the "Cat Crackers" are setting records one after another for length of runs. Consequently some means had to be found to keep thermocouple wells in lines of severe service during the long runs.

The thermocouple guards, which were 3-in. angle-iron per contractor specifications, were redesigned to break the catalyst flow as smoothly as possible, thus cutting down on the eroding effect. The point had to be considered that if the guard was made too big, the thermocouple would be pocketed in a dead space, thus losing its sensitivity to temperature changes. An iron-wedge guard 10½-in. high, 2¼-in. wide, and 8-in. long was installed with the knife edge facing the flow 1-in. upstream of the thermowell. This was found to outwear all designs tried. Tests on alloy coating of the wedge guards are under way at present.

The long duration of the "Cat Cracker" runs made the aforementioned experiments very slow; it was sometimes well over a year before we could see the results of our ideas. Thus, additional means had to be employed to keep the thermocouples in these lines after the catalyst had eroded through both the guards and the well.

A removable thermocouple-well assembly was devised, consisting of a 1½-in. collar welded to the line, to which was screwed a special 1½-in. x 3-in. nipple, a 1½-in. gate valve with a steam connection in both bonnet and bottom, a special 1½-in. barrel with 2-in. stuffing box on the outer end and a steam connection on the vessel side of the packing, a packing gland, and a special 25-in. ball-and-socket thermocouple-well without taper. A ¾-in. cock, installed on the head end of the thermowell, could be closed if the well tip eroded away. The thermocouple well projected 6 to 8 inches into the line. As the barrel assembly is larger than this, it is possible to loosen the packing and pull out the well far enough to permit closing the 1½-in. gate valve before the eroded part of the well came into contact with the packing.

As the reactor carries only 15 psig., the packing is always in contact with the good part of the well. Snuffing steam (steam used to snuff out a fire) is used at 3 points on



NOVEL, *FAST* ELECTRONIC WEIGHING SPEEDS ALLOY STEEL MIXING

To produce small batches of alloy steels to exact chemical analysis, this steel maker built Baldwin SR-4 Load Cells into ladle supports. As needed, the weight of molten metal is quickly, accurately read on an indicator in a control pulpit . . . the exact amount of alloy to be added is determined, as is the number of ingots that can be poured.

Great economy has been realized . . . efficiency increased . . . alloy composition accurately predetermined.

Wherever there is a difficult problem in measuring torque, pressure, explosions, depth, weight, others, SR-4 measuring devices frequently offer an easy solution. Write for full information.

BALDWIN-LIMA-HAMILTON

TESTING HEADQUARTERS

Philadelphia 42, Pa.

In Canada: Peacock Bros., Ltd., Montreal, Quebec

---

recorders

RECORD TIME • COUNT QUANTITY AND WEIGHT

Actuated by an electrical impulse . . . operates on the output of a scaler, photo tube, limit switch or any similar device. Records counts with relation to time and quantity on a roll of tape . . . automatically resets to zero.

In Radioactive Research, it saves precious man hours and results in greater economy and efficiency.

In Industry it maintains a permanent record automatically, recording production and time each hour.

Whatever your counting problems, our Engineering Department can adapt these Recorders to meet your particular need.

AUTOMATIC WEIGHT RECORDERS SINCE 1888

Write for interesting Booklet SC 13

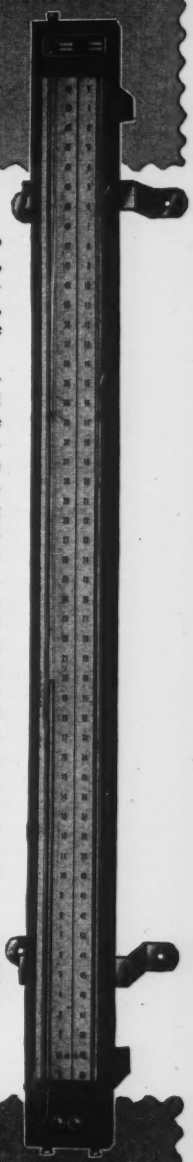
STREETER-AMET COMPANY

4101 N. RAVENSWOOD AVENUE • CHICAGO 13, ILLINOIS

SCALES • WEIGHT RECORDERS • HI-SPEED COUNTERS

Announcing the DUAL-TUBE

Something Brand New in MANOMETERS by MERIAM



● Now, instead of standing on a step ladder—as when reading long range, single column manometers—the operator can read high range pressures, vacuums, and differentials from the floor level.

This new manometer development—the DUAL-TUBE, Meriam Model M-100 — consists of two separate manometer tubes in the same case—each tube with individual well. The left tube has a scale increasing upward; the right tube a scale increasing downward. Both tubes are connected in parallel to the same pressure source.

The instrument is ideal as a calibrating standard manometer for checking flow meters, pressure gauges, and other secondary units operating on pressure or vacuum principle. It is direct reading. Since both tubes indicate the same reading, the operator can choose the one most convenient.

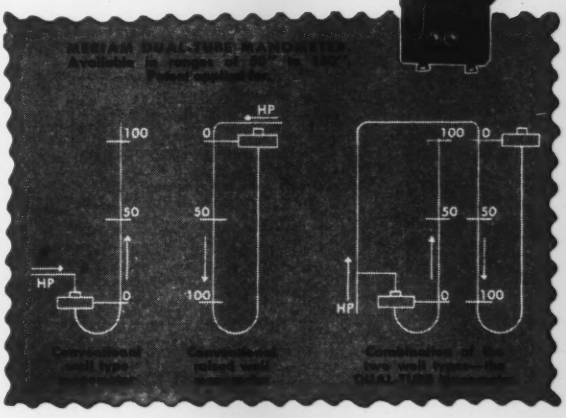
It helps avoid accidents, saves time and effort in reading. Of simple, rugged construction, it is built in accordance with Meriam standards of accuracy and sensitivity for long, reliable service. Ask for Catalog Sheet M-100WM.

THE MERIAM INSTRUMENT COMPANY

10958 Madison Ave. • Cleveland 2, Ohio

WESTERN DIVISION: 4760 E. OLYMPIC Blvd., LOS ANGELES 22, CALIF.

IN CANADA: PEACOCK BROS., LTD., MONTREAL

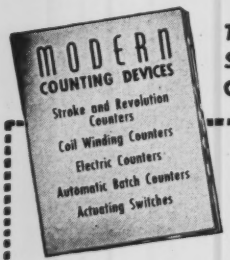


The "manufacturer's" gauge—
For years Marsh Gauges have been first choice of manufacturers of controls and other equipment where pressure indication plays a vital part. Their use on your product is a mark of distinction.
The finer construction of Marsh Gauges is not limited to costly types, but is common to the entire line in square relationship to the service for which they are recommended. All—regardless of cost—are quality instruments.
Write for this catalog covering the broader Marsh line.
MARSH
MARSH INSTRUMENT CO.
Sales affiliate of Jas. P. Marsh Corp., DEPT. 42, SKOKIE, ILL.
Export Dept., 155 East 44th Street, New York, New York

BETTER beyond comparison
say thousands of users

Used by the thousands in Auto and Aircraft Factories, Metal Working, Die Casting, Plastic Molding and Stamping Plants.

Rugged as an army tank, yet operate smooth as a watch.
Precision built of life-tested Materials.
Tamperproof Reset.
Streamlined—All steel housing.
Complete range of models.



PRODUCTION INSTRUMENT CO.
702 W. Jackson Blvd., Chicago 6, Ill.
Please send Catalog of Silver King Counters and Brief Catalog MODERN Counting Devices.

Company_____
Name_____ Title_____
Street_____ City_____ Zone___ State_____
SK-11

the assembly. This was found to be a safe method of changing thermocouple wells during unit operation.

Noise Reduction in Catalytic Cracking Units

The solution to the problem of reducing the noise level on our catalytic cracking units was associated with a second problem, which was that of automatically controlling the regenerator pressure. The excessive noise in the original installation was caused by high velocities due to a 6-psi. pressure drop. This drop was divided into separate smaller drops to reduce the noise level.

The 6-psi. drop in the flue gas stacks was divided into 3 steps: (1) A 2-psi. drop across the original butterfly valve, (2) a 1-psi. drop across the conventional orifice plate, and (3) a 3-psi. drop across the new Chapman slide valve. This reduces the velocity at each point with a corresponding decrease in noise level. It is now possible to hold conversation at the base of the stack.

The new Chapman slide valve was manufactured with two slides on opposite sides of the body—one slide is operated manually; the other operated automatically by a pressure controller.

Instead of operating the slide valves with conventional hydraulic valve positioners, it was decided to try a reversible rotary air-motor mounted directly to the handwheel shaft. The motor is actuated by a conventional null-balance control-valve positioner that operates an air pilot valve controlling the 50-psi. air supply to the air motor. This system has great possibilities. It eliminates the fire hazard of hydraulic fluid and also the maintenance of a separate system because an air supply is already available where pneumatic control instruments are used.

We are able to justify installation on the basis that the regenerator can be run at ½-psi. higher pressure if it can be controlled automatically. The ½-psi. increase in pressure represents a calculated 2-percent increase in regenerator capacity due to decreased velocities at the higher pressure. Actually, the installation has paid off in two ways—noise-level reduction and increased capacity.

Mixers

One of the problems encountered in our Treating Plant was the inflexibility of the conventional mixer. The mixing problem that was called to our attention was on the kerosene-treating unit, where we were acid-treating the kerosene. It was found that the actual acid rate could be held constant, and sometimes even decreased, as kerosene rate was increased. We were asked to design a mixer for this service.

The final mixer used was a double-seated control valve with a poppet-type plug operated by a differential-pressure controller with taps up and down stream of the control valve. It was found necessary to reverse the control valve in the line to form a mixing chamber for best mixing. This has proved satisfactory for all operating conditions, and the quality of our kerosene has been decidedly better since the installation was made. It is our opinion that a single-seated control valve with a poppet plug would be more desirable for the service. Consequently, we have replaced several mixers in the plant with manually operated globe valves. These have proved satisfactory and have the necessary operating flexibility.

Discussion

J. M. Jones: I would like to ask Mr. Mattix to describe further some of the problems he encounters in measuring and controlling pH. I have in mind the tricks of the trade. pH is one of these problems that we would rather not tackle, but we have to do it.

E. D. Mattix: We did run into considerable difficulty in the beginning. One thing done was to put airbleed into the top of the cell to keep moisture condensation off the leads. Also, we originally took the sample from the liquid-level control line. We found that the surge in the flow rate there either caused difference in the level of the cell or possibly reduced the pressure on the material. As this caused a change in pH reading, the sample connection was

NEW . . .

WELTON INSTRUMENT SOLDERING PASTE

A SOFT SOLDER for Hair Springs, Instruments and Many other Components

NO CORROSION AFTER SOLDERING

This material is intended specifically for soldering electrical instrument small parts such as instrument hair springs and other small parts, many of which are made of materials that are considered difficult to solder, such as beryllium copper, where rapid heating and a localized application of solder is dictated.

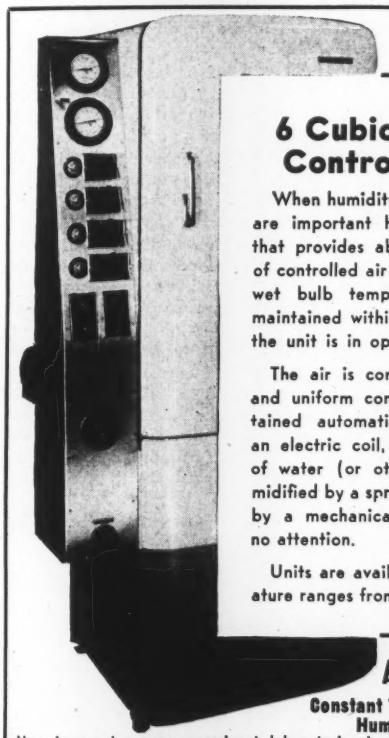
Packaged in 4 ounce wide mouth glass jars, with instructions on the label.

Quantity—4 Ounce Jars	Price per Jar
1— 5	$2.25
6—11	2.00
12 and over	1.90

F. O. B. Summit, New Jersey. Prices of larger quantities upon request.

Welton V. Johnson
ENGINEERING COMPANY INC.
95 SUMMIT AVENUE • SUMMIT N. J.

Our line includes: Instrument Type Precision Parts (Shafts, Pivots and Tubes)—Centerless Grinding—Swiss Screw Machine Parts—Heat Treating—Polishing—Swadging—"Weltonoil" Treated Buttonwood Pith—Thread Rolling—Knurling—Burr Free Tube Cutting. ENGINEERING DESIGN ASSISTANCE RENDERED ON ALL ITEMS PERTAINING TO OUR ACTIVITIES.



6 Cubic Feet of Controlled Air

When humidity and temperature are important here is a cabinet that provides about 6 cubic feet of controlled air . . . both dry and wet bulb temperatures can be maintained within 1° F as long as the unit is in operation.

The air is constantly circulated and uniform conditions are maintained automatically; heated by an electric coil, cooled by a coil of water (or other coolant), humidified by a spray chamber, dried by a mechanical device needing no attention.

Units are available with temperature ranges from 40° F to 140° F.

AIRE-REGULATOR
Constant Temperature and Humidity Cabinets

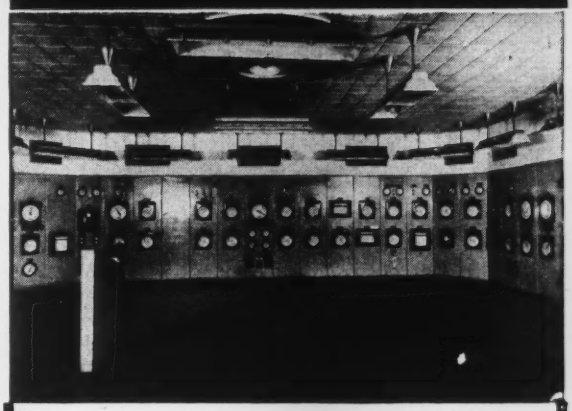
Now in use by many prominent laboratories in food, research, paint, pharmaceuticals, etc.—names on request. Write for bulletin and tell us your requirements.

Food Technology Inc. 5915 Northwest Highway Chicago 31, Illinois

for electrical control applications

it's KIRK AND BLUM

FOR SHEET METAL ENCLOSURES



If you need an enclosure for one, two or three instruments, or hundreds of instruments, call on KIRK & BLUM for fast, accurate fabrication. The photo above shows a typical large installation. Almost 100 instruments and controls are visible in this installation in a major refinery.

KIRK & BLUM is equipped and experienced to fabricate one unit or hundreds, specializing in custom-built parts and assemblies of sheet steel, light plate, stainless aluminum, monel and other alloys in gauges 3/8" and lighter.

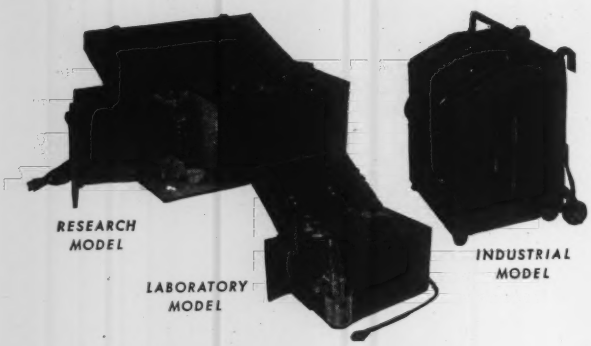
For more detailed information, write now for your free copy of the NEW Kirk & Blum Electrical Enclosures booklet.

- **Control Desks • Cubicles • Electrical Cabinets & Enclosures**
- **Power Distribution & Control Panels • Switch Gear Housings**
- **Boiler, Generator & Turbine Control Plants**
- **Louvres**
- **Test Stands, Controls & Desks • Instrument Panels**
- **Outdoor Electrical Enclosures**
- **Transformer Tanks**
- **. . . and other Fabricated Products**

For prompt quotation, send prints to:

THE KIRK & BLUM MFG. CO.
3111 Forrer St. Cincinnati 9, Ohio

KIRK AND BLUM



Cambridge pH Meters

The three portable models illustrated above incorporate new and important advantages. A.C. line operation eliminates battery nuisance. Laboratory and Research models use electron-ray tube for precise null-point indication. Industrial model is direct-reading, continuous-indicating; ruggedly built for plant use.

Accuracy: Research .02 pH, Laboratory .05 pH, Industrial .10 pH. Cambridge pH equipment also includes single- and multi-point indicators and recorders. Send for Bulletin 910-MR.

CAMBRIDGE INSTRUMENT COMPANY, INC.
3742 GRAND CENTRAL TERMINAL, NEW YORK 17, N. Y.

Pioneer Manufacturers of
PRECISION INSTRUMENTS

NEW Metron HAND TACHOMETER *for the*

"MOST-USED" SPEED RANGES!

★ R.P.M. and F.P.M.: 100-1000; 200-2000; 500-5000. F.P.M.: 10-100; 20-200; 50-500.
★ WITH ADAPTERS: As Low as 10 R.P.M. As High as 50,000 R.P.M.
★ SELF-CALIBRATING
★ FAST RESPONSE—for Acceleration Tests
★ UNDAMAGED BY OVERSPEED
★ 1% ACCURACY—All Ranges
★ DRIVE TORQUE REQUIRED only 1/15 ounce-inch!

HERE is the Metron Model 25-D Tachometer for testing (without range adapters) in the "most-used" speed ranges, such as those encountered in motor and generator testing, process control and maintenance work . . . A new instrument with all the famous Metron simplicity, accuracy and reliabilty. All-electric, non-generating circuit has *only one* rotating part, permanently lubricated. Unaffected by vibration, humidity, temperature or magnetic fields. The perfect tachometer for year-in, year-out shop or laboratory use.

Metron Model 25-D is furnished in a rugged, attractive carrying case, complete with accessory tips, extension, feet-per-minute discs and instructions.

Write today for Bulletin 103!

METRON INSTRUMENT COMPANY
437 Lincoln Street • Denver 9, Colorado

Metron INSTRUMENTS FOR PRECISION MEASUREMENTS

taken from the main drum after that. The instrument originally had second derivative, but owing to the occasional slight change in pressure on the tower, the second-derivative function was never operated because it did the wrong thing at that particular time. Therefore, that feature was eliminated in this control application. The instrument man in charge of the instrument was inclined to keep his trade secrets to himself. If you want to get them, go and talk to him; he can give them to you.

Jones: Do you use a reversing cycle of the steam air to heater tubes?

Mattix: To date we have not. I would like to ask Mr. Jones if he thinks this a desirable procedure. We have much to learn yet on this procedure.

Jones: We have used steam-air decoking of heated tubes for a number of years. We found that we could materially reduce the time of decoking by first cycling through in one direction, and then reversing the operation so that the steam and air came in from the opposite direction. It seems to hold down the period of time that you have to carry your tubes at the high temperature necessary to burn the coke out of the tubes.

Jones: Mr. Mattix, in connection with your anti-pumping device, or rather with your elimination of your orifice plate in the suction to your blower, was that orifice plate primarily an anti-pumping device, or was it for measurement of flow and control?

Mattix: The orifice plate was a device put in the blower suction for measuring the rate of air and controlling the turbine speed to control that rate.

Wheelis: How did Mr. Mattix calibrate the reducing section after he removed the orifice?

Mattix: Fortunately, we had meters on all of the points of major consumption of air in the unit. We were able to add these up and come out with the factor. The only difficulty was that we had a modified flow nozzle at one location, and the factor on it was questionable in our minds.

Gallager: The question of erosion of thermocouples in catalyst lines is one that many people have been confronted with. I thought I would pass on here that we couldn't get stainless steel. We started with carbon-steel couples in a lot of wells, and they went out pretty fast. Various means were used to shield them, and we found that sometimes the shielding did more harm than good; eddies would chew the couple up, and it circled the catalyst around rather than just hitting it once. The next thing tried was to go to higher Brinell materials. We know the Brinell falls off as metals go up in temperature, but we use some 440-stainless 500 Brinell. In some cases it was stellited as a separate layer, and well life was increased considerably. My second point is on the noise-level problem when you are releasing the flue gases to the atmosphere to a pretty good pressure drop. Our solution was similar to what was done by Mr. Mattix—that is, taking the pressure drop in two or three steps. Somebody calculated that if you stay below 2 pounds pressure drop, you can keep on carbon steel, and you can keep out of erosive velocities with the small amount of catalyst that was there. We gained two-fold—the noise level went down and the erosion across the valves also went down. The third point is a question. The question, Mr. Mattix, is what velocity do you recommend on the suction to your blower to reduce the noise level to a tolerable one. Do you have any figures on that?

Mattix: I am afraid that I don't have any exact figures on that. In fact, on our catalytic crackers we could never hear the blower suction until we had made the changes on our stack. It was only after that that we could hear the blower suction, so we have not gone into that one yet.

Gallager: Did reducing the velocity at the inlet to the suction increase your noise level?

Mattix: We didn't change the size of it at the inlet. We had already had a reduction piece on the inlet to begin with, and all we did was increase this section of pipe. No, we couldn't hear the blower prior to that because of the noise of the stack.

McLean: I would like to know if you have a sketch of the steam-air decoking setup. I would like to have a brief explanation of it.

with a **LIQUIDOMETER** *Tank Gauge*

- FOR GAUGING LIQUIDS OF ALL KINDS
- 100% AUTOMATIC
- APPROVED BY UNDERWRITERS' LABORATORIES

WRITE FOR COMPLETE DETAILS

THE LIQUIDOMETER CORP.
36-27 SKILLMAN AVE., LONG ISLAND CITY I, N.Y.

Mattix: No, I do not have a sketch. However, I will briefly sketch it on the board. We had here the coil inlet, and the temperature was increased on the flue gas until it reached approximately 1,000 degrees on the stack. In the initial decoking operation, steam alone is injected into the inlet. It comes out here, and we add water at this point to cool the temperature below 200 degrees. On the inlet then, when you actually go to the steam coking cycle after the spalling has accomplished all that can be accomplished that way, you have an air line and a steam line going into the inlet section—a manual valve on each, and an orifice with a flow recorder on each stream. So far, we consider the flow recorder quite valuable. I understand other refineries do the same job without it.

J. R. Martin: What material is available for calculations on the modified venturi?

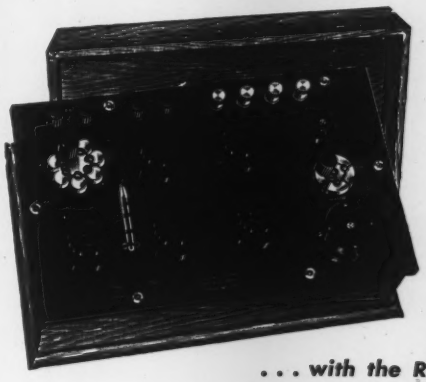
Mattix: After going through various text books, we were unable to find such a thing as a standard venturi. Our calculations came within the normal 4 to 6 percent you expect on a venturi. I think it is recommended that all venturis be calibrated after their design.

E. L. Williams: In discussing the problem of pH control, a lag is shown. Is any of that lag in the instrument, or is it all in the process.

Mattix: I presume there is some lag in the instrument because of the volume of liquid in the cell. The cell holds about a quart. As we had approximately a gallon per minute flowing through it, that probably causes a delay of a fraction of a minute. However, we found the same type of curve when we took samples and ran the samples manually by indicator color. This chart was used only because it illustrated what was happening.

J. M. Jones: I might state here that the lag in the pH electrode has been reduced further by a development of a different type of flow cell. It uses the same electrodes, but the housing does not hold an appreciable quantity of liquid. It is about the size of quarter-inch line throughout.

Precise
TEMPERATURE MEASUREMENTS

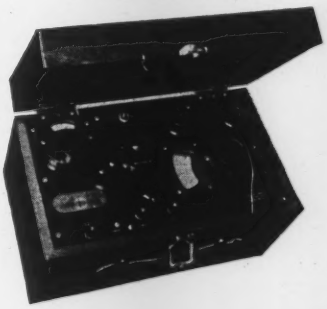


. . . with the Rubicon MUELLER BRIDGE

A highly accurate and specialized form of the Wheatstone bridge designed expressly for precise resistance thermometry with three- or four-lead thermometers and for the measurement of other similar resistors within its range.

- Wide range: 0 to 71.1110 ohms in increments of 0.0001 ohm
- Unity ratio with provision for convenient checking and precise adjustment of ratio arms
- Built-in mercury commutator for lead resistance compensation
- Sub-panel switch construction
- Built-in plug and block assembly for conveniently checking ratio, bridge zero and thermometer resistance with no disturbance of external bridge connections

Described in Bulletin 100



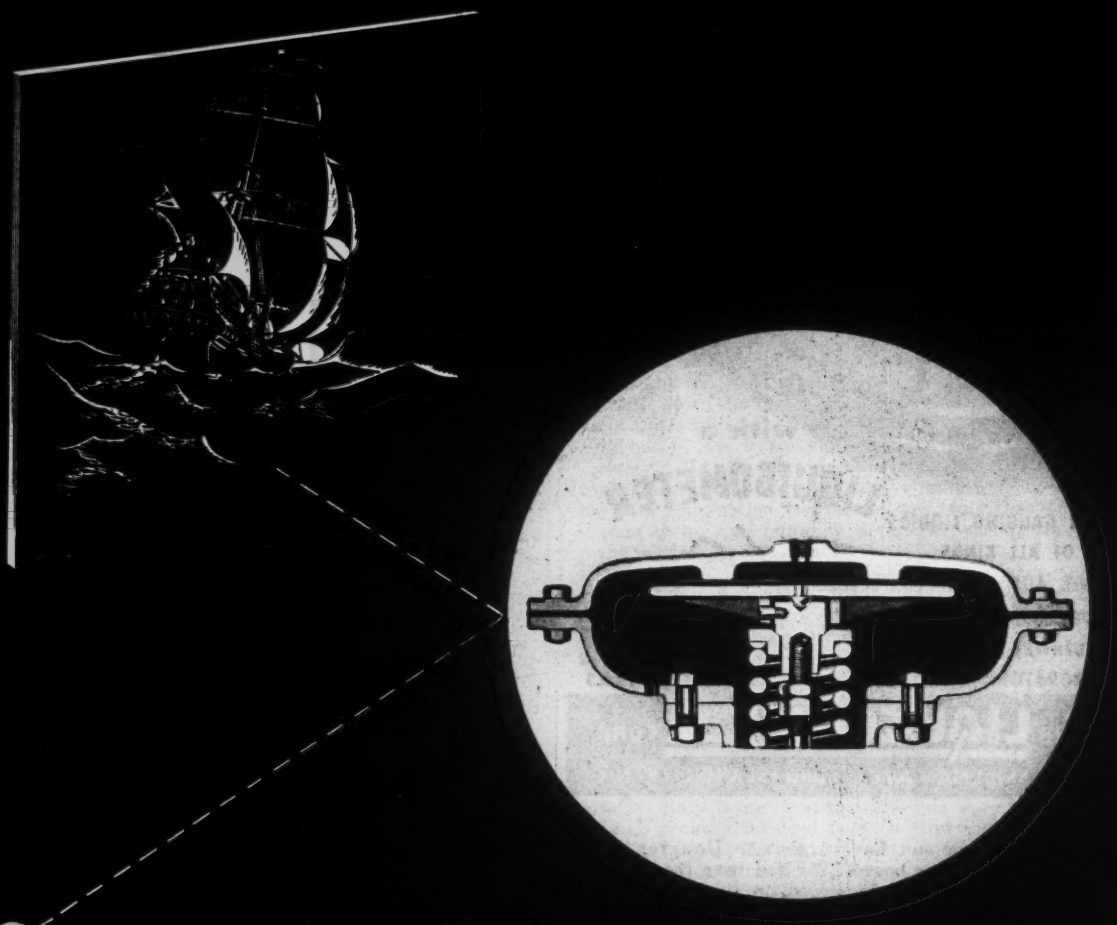
. . . with the Rubicon PORTABLE PRECISION POTENTIOMETER

A two-dial instrument of exceptional accuracy and sensitivity.

- High-sensitivity, sturdy, built-in Pointerlite galvanometer—permits balancing to within 2 microvolts in low resistance circuits
- Completely self-contained assembly—no external accessories except the thermocouple circuit
- Two ranges —0 to 16.1 and 0 to 161 millivolts—readable to within 2 and 20 microvolts respectively
- Sturdy, compact construction for long dependable service

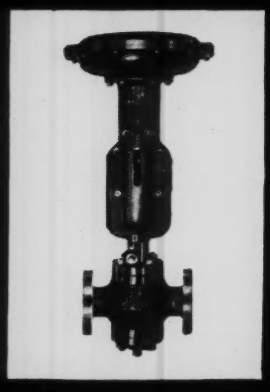
Described in Bulletin 270

RUBICON COMPANY
Electrical Instrument Makers
3755 Ridge Avenue • Philadelphia 32, Pa.



ROLLING ACTION . . .

for superior spring-diaphragm characteristics



The pre-moulded neoprene diaphragm in the Honeywell Series 700 Valve features rolling action . . . eliminates wrinkling or buckling . . . responds to slightest change in signal air pressure . . . may be used with either air or gas as actuating medium. The Honeywell Series 700 Valve is available in a wide range of styles and sizes . . . has *all* the features you look for in a fine valve. Write today for your copy of Bulletin 700-3.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 1908 Windrim Ave., Philadelphia 44, Pa.

MINNEAPOLIS

Honeywell

VALVE PRODUCTS

First in Controls

H HONEYWELL

Volume 8 January 1952 Number 1

Journal

Officers

President: A. O. Beckman

First Vice-President: W. A. Wildhack

Vice-President: D. M. Boyd, Jr.

Vice-President: N. L. Isenhour

Vice-President: R. T. Sheen

Secretary: Porter Hart

Treasurer: G. R. Feeley
ISA National Office, 1319 Allegheny Avenue, Pittsburgh 33, Pa.

Manager: P. V. Jones

National Committees and Chairmen

Committee for Analysis Instrumentation, D. J. Pompeo; Constitution & Rules & Procedures Committees, R. J. S. Pigott; Coordinating Committee, E. S. Lee; Employment Committee, C. F. Goldcamp; Finance Committee, J. T. Vollbrecht; Historical Committee, L. M. Susany; Instrument Maintenance & Operation Committee, J. Johnston, Jr.; Committee on Instrumentation for Production Processes, W. H. Brand; Instrumentation for Testing Committee, D. C. Little; Instrumentation for Transportation Committee, F. H. Catlin; Instruments for Inspection & Gaging Committee, W. A. MacCrehan; Meetings Committee, E. J. Grace, Jr.; National Defense Committee, R. L. Goetzenberger; Nominating Committee, M. S. Jacobs; Publications Committee, C. W. Covey; Recommended Practice Committee, A. V. Novak; Sections & Membership Committees, M. S. Jacobs; Society Structure & Planning Committee, A. H. Shafer.

TABLE OF CONTENTS

Power Plant Instrumentation 92
Turbine Governors as Related to Pneumatic Controls, by J. A. Pellettere 92
Section Secretaries and Meeting Data 96
Cleveland Show Gets Under Way 97
First ISA Corporate Member 97
Employment Service 97
Caribbean Instrumentation Conference 98

THE MANAGER'S PAGE

Percy V. Jones

THE new title of this page serves to call your attention to the change that has taken place in the management of your National Office and with it the responsibility for the *ISA Journal*. Since it will be sometime before I have the multitudinous duties of my office sufficiently in hand to permit me to get around to meeting more than a handful of our thousands of members, I shall have to use these pages to become acquainted with you.

My first knowledge of the scope of ISA activity was obtained during the Houston Show, where I had the opportunity not only to meet and talk with several hundred members but also to obtain an introduction to the best planned and executed meeting it has been my pleasure to attend. Ever since my arrival in Pittsburgh I have been made increasingly aware of the tremendous strides already taken by ISA, and of its almost limitless opportunity for future expansion, not only in point of membership, but in service to the field of instrumentation.

The position of Society Manager presents a challenge and a tremendous opportunity for service. The first, I cheerfully accept—the latter will be fulfilled with your cooperation.

I hesitate to predict the growth of ISA during the next five years, but I am very pleased that I have the opportunity to take a part in developing its bright future.

New Dues Rate Effective March 1, 1952

In its meeting of December 2, 1951, the Executive Committee (now the Executive Board) decided that it would not be practical to have the new dues rates take effect immediately but that some time lag would be necessary in order to advise each member through notice in the *Journal* as to the results of the ballot. It was therefore, determined to have the new dues rates go into effect on March 1, 1952. Thus, renewals of memberships due March 1, 1952 and later, and new membership applications received in the National Office after February 29, 1952, will be subject to the dues rates specified in the new By-Laws.

A total of 1390 ballots voting on the new constitution were received in the National ISA Office as of December 8, 1951. Of this number 1228 voted to accept the proposed amended version of the Constitution dated September 10, 1951 and 162 voted to the contrary.

In view of the above results the new ISA Constitution and By-Laws became immediately effective.

Power Plant Instrumentation

Six technical papers will be featured at the annual Regional meeting sponsored by the New York Section ISA, to be held at the Hotel Statler, New York, N. Y. on February 7 and 8, 1952. The technical program will start at 10:00 A.M. Everyone interested in the general topic will be welcome.

A registration fee of $3.00 per person will be assessed for the two-day conference—registration starts at 9:30 A.M. A banquet will be held Thursday evening February 7, 1952. The speaker at the banquet will be Rear Admiral William S. Maxwell USN. (Ret), Deputy Director, Bureau Smoke Control, Dept. Housing, City of New York, whose subject will be "Smoke Screens."

The program is as follows:

1. "Management Yardstick for Instrument Costs" by A. L. Keiler, E. D. Keiper, S. V. Agnes, Socony Vacuum, New York.

2. "Maintenance of Controls and Instruments for Safe Operation of Power Boilers" by T. R. Hardin, Chief Engr., Hartford Steam Boilers Inspection and Insurance Co., Hartford, Conn.

3. "Instruments for Power Plant Water Treatment" by V. J. Feeney, Burns & Roe, New York.

4. "Organization & Scope of Instrument Repairs for Power Stations" by Al Jerks, Consolidated Edison, New York.

5. "Some Considerations in Determination of Excess Air" by C. P. Lugrin, T. T. Frankenburg, R. P. Marche.

6. "Automatic Logging, Enunciation and Recording for Power Plants" by Stanley Kroll V. P., Taller & Cooper, New York.

Permian Basin Section Granted ISA Charter

The Executive Committee at its regular meeting held in the Statler Hotel, New York, on December 2nd, upon recommendations of the Sections and Membership Committee, approved the Charter application of the Permian Basin Section, located at Odessa, Texas.

M. G. Gibson, Odessa, Texas is President and J. B. Jenkins, Secretary of ISA's newest Section.

Turbine Governors As Related To Pneumatic Controls

By J. A. PELLETTERE*

IT IS increasingly apparent that some control engineers are becoming impatient with the slowness of turbine manufacturers in providing proper interconnection of pneumatic control systems and prime movers. Recent technical literature indicates that some engineers are willing to discard the present hydraulic governor in favor of an all pneumatic system; many are leaning toward a simple flyball converter of shaft speed into air pressure as the beginning of this all-pneumatic governor system.

It is felt with considerable conviction that this situation is to be regretted. Far too much good engineering has been incorporated into the hydraulic systems for these systems to be summarily discarded.

Need for Governors

In electric power generation plants, governors for turbo-generators were designed to maintain constant speed under varying load conditions. The frequency characteristics of the current generated demanded governors with high quality speed regulation. Industrial uses of driven pumps, compressors, and the like, differ in that very often, good regulation is required at varying speeds as well as at varying loads.

Oil was required for bearing lubrication and cooling, so it was only a short step to make use of the oil pumping system to hydraulically govern the turbine. The use of high steam pressures and temperatures resulted in a very well designed steam admission valve system. Overspeed protection was provided, with or without a separate steam cut-off valve.

Does it appear logical to set aside the majority of this proven equipment in favor of a complete pneumatic system—especially since pneumatic systems are burdened with their own inherent lags?

But industry, today, is using pneumatic systems to the best possible advantage in the field of controls, and it does appear that it should be possible to properly inter-tie the pneumatic with the various hydraulic systems of turbine governors.

Present Confusion

It is at this point that some rather serious confusion begins to show up. When a user applies an air impulse to operate a turbine governor, it is very often disappointing to note that some of the finer features of the governing system are retired to stand-by or pre-emergency service. Too often the customer has chosen the wrong type of governor due to conflicting versions or definitions of the terminology of the trade. Admittedly, the wording of the specification is a chief source of the troubles. To draw up good specifications, some of the terminology should be set straight so that user and governor manufacturer have a common basis of understanding.

Definition of Terminology Used

When the various turbine governor specifications are compared, it will be noted that words and phrases such as *relay, hydraulic, constant speed type, variable speed type, regulation,* and many others appear to be used with meanings that are different for the manufacturer and for the user. Consequently, in the discussions between the manufacturer and the user, each has his own version of the requirements. This results quite often in a poor performance unit, especially when on instrument control, and the turbine manufacturer is unable to aid the problem due to his lack of understanding of the users' desires or needs. (See attached terminology chart).

Just what is meant by the word *relay?* Any dictionary will define it as a device by means of which feeble forces can regulate forces of greater magnitudes. With this definition in mind, it can be stated that the average hydraulic governor can contain two relays: one usually operates in conjunction with a primary element such as the flyball; the second usually is a part of the mechanism for positioning the steam valve. An internally-balanced steam valve could be called a relay, conceivably, since it too conforms, in part, with the definition. However, this paper will not consider the internally-balanced steam valve as a type of relay.

The terms *constant speed governor* and *variable speed governor* are self-explanatory only insofar as the general description are concerned. There can be numerous classes of governors that will fall into one or the other of these two types, but neither type is exclusively *hydraulic.*

What is meant by the term *hydraulic governor?* When compared with the simple shaft or mechanical governor, the differences are obvious.

But consider, for the moment, a so-called hydraulic governor with its necessary flyball, relays, and servomotor. Assume that the governor is equipped with a diaphragm motor so as to control from a pneumatic instrument, and that, when on instrument control, the flyball and hydraulic components are retired to stand-by service. When a pneumatic impulse is used and a diaphragm motor acts to position the steam valve directly through mechanical linkage, can this governor still be called *hydraulic?* One manufacturer who is a leader in the field does this in one of his highly advertised units.

*Gulf Oil Corporation

Presented before the Sixth Annual Conference of the Instrument Society of America, at Houston, Tex., Sept. 10-14, 1951.

Statements expressed herein are those of the author and not necessarily those of the Society.

Variable Speed vs Constant Speed

Another point of confusion is when to specify variable speed type in preference to constant speed type. Does the introduction of pneumatic control automatically change the specifications from constant speed to variable speed type? Or should it be considered in the light that the pneumatic controller merely resets the control point of the constant speed governor? Should the latter be a correct interpretation, there would be no need of change in classification.

In general, constant speed governors make use of a flyball as the primary element. When the customer specifies a constant speed type of governor with air pressure modulation, some manufacturers are at a disadvantage due to lack of rangeability of their particular flyball mechanism. In such a case, the manufacturers quote a governing system which retires the flyball to stand-by or pre-emergency service.

In the opinion of the author, the above procedure does not tend to provide the better governor. The normally fine degree of regulation possible with a good hydraulic governor will be set aside in favor of the regulation made possible by the primary pneumatic controller with its attendant transmission and output pressure lags.

Elements of a Governor System

There are three basic parts to a governor, namely: (1) a speed operated primary device; (2) suitable linkage, whether mechanical or hydraulic, between the primary device and the steam control valve; and (3) the steam control valve with its power unit (the servomotor). The linkage between the primary device and the steam control valve may be termed a steam valve position transmitter. The secondary device is some means of transferring the output of the primary device or primary device motion so as to effectively position the power operated steam valve in accordance with the speed change.

Other parts related to a hydraulic governor are: hand speed changer; a pneumatic device for adapting the air impulse from a pneumatic controller; a low oil pressure trip-out mechanism; and, in some cases, a stand-by oil pump to protect against low oil pressure. The stand-by oil pump, while primarily for lubricating service, also provides stand-by hydraulic power for operating the governor.

The hydraulic designers also have made available a positive throttle-trip valve with single seated, tight shut-off characteristics. It can be used as the hand throttle during start-up, and also to provide a positive shut-off in the event of overspeed.

A mechanical overspeed trip is available for the simple, mechanical type governors.

Types of Governors

The author has made sketches showing four typical American manufacturers' types of flyball governors: Fig. I shows (1) a mechanical, (2) a hydro-mechanical, (3) hydraulic type wherein the flyball generates an output oil pressure, (4) a hydro-mechanical wherein the flyball also produces a speed modulated oil output pressure. Most of us are familiar with the Type 1 so-called mechanical shaft governor which is usually used in low horsepower equipment and has about a 15 per cent change in speed range and can be modulated by an air motor or hand speed changer so as to make use of the same speed range.

General Types of Hydraulic Governors (See Fig. I)

In Types 2 and 4, the flyball positions a lever which in turn operates the steam valve servomotor mechanism. Type 2 differs from Types 3 and 4, however, in the fact that the flyball in Type 2 does not produce a speed modulated oil pressure but does use a relay to position the transmitting lever. Type 4, like Type 3, has a flyball whose speed produces a proportionate oil discharge pressure.

These two flyball operated units are common only to this extent. In Type 3 the hydraulic output pressure is allowed to pass through a pipe as a transmitter (secondary) to the servomotor. This makes a rather neat appearing job since it is more or less free of levers or bearings until the large multi-port steam valves come into the picture.

Type 4 has a flyball which produces an oil discharge pressure from speed and uses in a hydro-mechanical feedback system in such a manner that the flyball has a wide range of operating speeds. A speed turn-down ratio of 4 to 1, in such a system as this type, by hand or by air motor operation, is achieved easily. Note that in Type 2 and Type 3, the flyball is allowed to do no work by becoming a pre-emergency device when the pneumatic instrument is called upon to do the controlling. In the case of Type 3, this is rather unfortunate since this particular manufacturer's flyball does have a wide turn-down range, and on the hand

TYPES OF FLYBALL GOVERNOR MECHANISMS

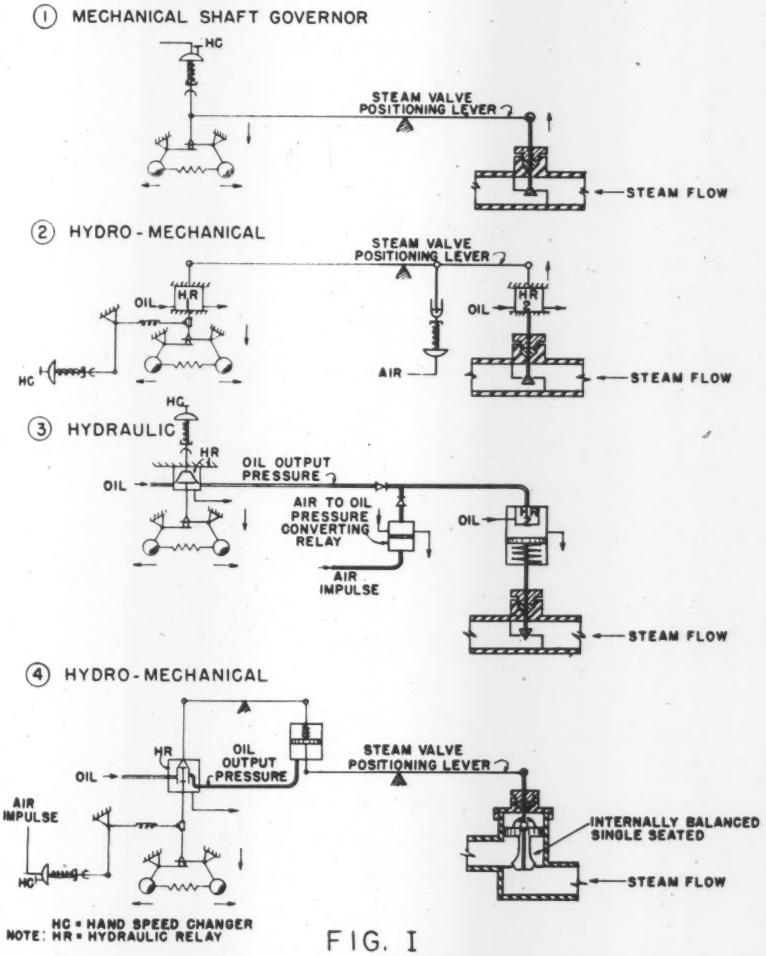


FIG. I

speed changer the flyball features are retained.

A summary of such studies indicates to the initiated that when the manufacturer has a low turn-down range flyball, he would rather apply the air motor to the transmitting lever and retire the flyball to a pre-emergency status. And in some instances, if the customer specifies that the hand speed changer must have a wide range of turn-down, the manufacturer must abandon the flyball in favor of the so-called orifice governor, unless regulation requirements prohibit.

Orifice Governors

In general, when the customer specifies a wide turn-down range without specifying a close degree of regulation, the manufacturer will quote on a hydraulic unit known as an *orifice governor*. An orifice governor is sketched in Fig. II, Type 1, and shows a primary element which differs from a flyball. The primary element here consists of some form of hydron mechanism which operates the transmitting lever to the steam valve either directly or through a relay. Fig. II, Type 1, shows the hydron directly coupled to the steam valve positioning lever and is basically the same type of unit offered by several manufacturers.

With the governor on manual control, the oil discharge valve from the primary element is adjusted to change the back pressure in the hydron. With the hand valve set, an increase in speed will automatically raise the pressure in the hydron, causing the steam valve to be moved toward the closed position. The pneumatic modulator consists of a small diaphragm operated valve in the oil line leaving the hydron.

Air pressure changes modify the outlet orifice from the hydron in such a manner that the oil pressure is changed in the hydron, controlling the speed in accordance with demands from the primary pneumatic instrument. This is a pneumatic setting of speed similar to speed setting as accomplished by the hydro mechanical flyball unit, Type 4 in Fig. I.

Characteristics of Orifice Governors

It is interesting to note that in the orifice governor it is possible to have the hydron position the lever, which in turn positions an internally-balanced steam valve without the oil-operated servomotor. This can be construed as a hydraulic governor with no true oil relay present. As mentioned before, the definition of relay is rather vague. One thinks of a relay as a mechanism wherein a flea powered circuit releases a high energy circuit to do work. In general, if the governor manufacturer supplies a governor with an oil "squirting" mechanism, it is construed by the trade to be an oil relay type governor. The average customer believes that an oil relay governor implies that the steam valve will be oil power positioned.

It might be well to bring out some of the points of interest with regard to the orifice governor. These are namely: (1) it is not easy to get a linear response of speed to air impulses; (2) regulation is not as good as with a flyball type of governor; (3) it is cheaper than the hydraulic flyball governor or the so-called constant speed hydraulic governor; (4) it is usually operated on hand speed changer and/or air impulses in its entirety with no pre-emergency features; (5) the orifice governors offer a large turn-down ratio; and (6) steam valve requires shop characterization to match load points of driven unit.

Results of Present Confusion

The manufacturer, at the present time, has a close-coupled, well-designed, hydraulic system, as evidenced by four per cent regulation guarantees. He who would design an all pneumatic governor and retire this hydraulic equipment is going to find it difficult to obtain four per cent regulation with a pneumatic transmission tube with the controls mounted at the receiving end. The control engineer should require that the governor vary the prime mover speed in accordance with demands from the primary instrument. The reasons for this will be brought out later.

Industrial operators of turbines, driving compressors or pumps to control flow in general, are not interested in speed control as such, but will eventually insist that the governing mechanism retain its characteristics when operated by the hand speed changer or the pneumatic impulse. Fig. I, Type 2 and 3, are wide range hydraulic governors which could easily meet these requirements but unfortunately the manufacturers have not connected the air impulse into the circuit in the desirable position. Other manufacturers have not seen fit to design into their flyball mechanisms a high range of turn-down.

These oddities are the results of the fact that in the past the turbine manufacturer has treated pneumatic control as a passing episode and gone about applying the pneumatic inter-tie to his 50 years of hydraulic experience, in the cheapest and easiest manner. The final outcome often results in retiring

TYPES OF COMMERCIAL GOVERNORS

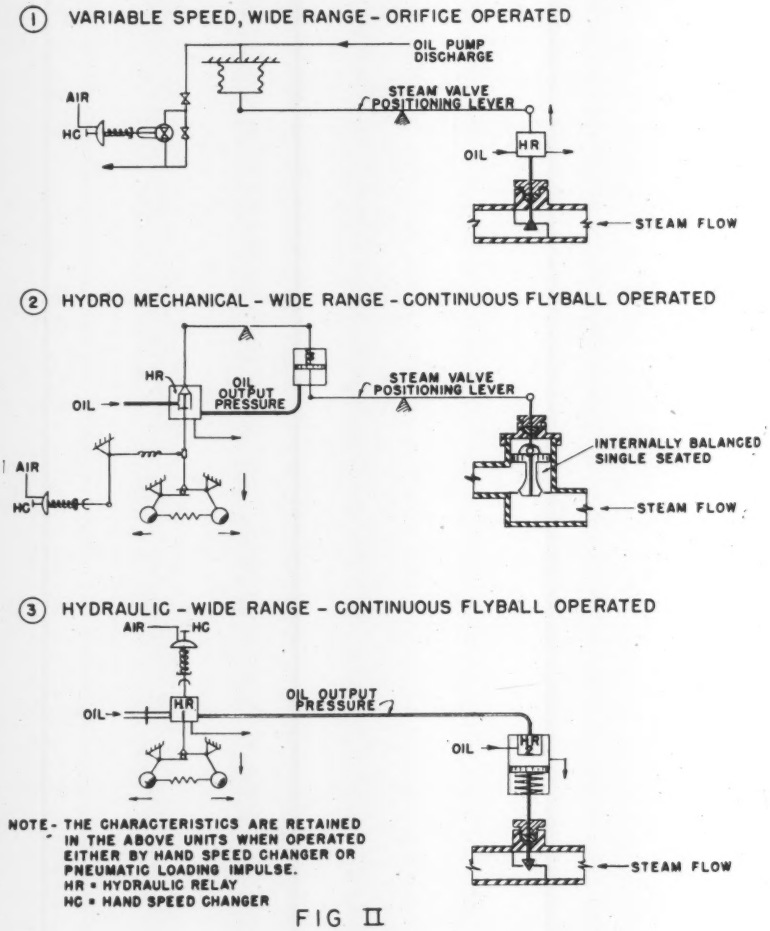


FIG II

the 50 years of hydraulic design to a so-called pre-emergency status when operating on pneumatic impulse.

In any critical control problem the control engineer should require not merely to position the steam valve, but to set the speed by air pressure. This means he desires to have the hand speed changer and the air motor work in a similar manner to achieve the end results, whether on hand or pneumatic control. It is obvious that for a high degree of regulation, the flyball must become a part of such a circuit and operate continuously.

Ideal Governor

To an instrument engineer, two ideal governors come to mind. In some respects he is interested in simplicity. A true hydraulic governor with no linkage, with the air motor moving the hand speed mechanism as shown by Fig. II, Type 3, is an idealist's conception of a simple, purely hydraulic, non-mechanical mechanism. One has to admit, however, that there must be linkage in a large multiple port steam valve positioning mechanism. Therefore, one concedes that Fig. I, Type 4, or Fig. II, Type 2, using a variable 4 to 1 flyball operated either by air impulse or by hand speed changer is also of considerable interest, especially when the importance of the job involved will bear the added cost.

Advantages of an Ideal Governor

The advantages of either of these two governors which pneumatically set the speed of a constant speed governor are:

(1) When one operates the hand speed changer mechanism with an air motor, the complete governor is used in its entirety and nothing is retired to a pre-emergency status.

(2) It is easy to build into such a governor a linear response of speed to air pressure change.

(3) The steam valve will not have to be shop characterized to meet the load, which is usually a pump built by another manufacturer.

(4) A "second-grade" servomotor which is not a full oil relay type but which operates well in the circuit for which it was intended (in connection with its flyball) will not malfunction when put on air control due to retirement of the primary element (flyball).

(5) Any changes in throttle steam pressure, turbine exhaust steam pressure, or steam quality are immediately corrected for, and without the aid of the primary (pneumatic) controller.

(6) Flyballs incorporated in such governors are capable of close regulation (2 to 4%) which obviates the need for derivative and reset functions in the governor itself.

Conclusions

The author's solution to the problem of the good governor design, as developed in this paper, is based on the theory of cascaded controls. Too often the control engineer begs to have the primary instrument set a flow controller instead of operating a control valve directly and is told that the secondary instrument (flow meter) is prohibited by the extra costs. All the instrument engineer can do in such an instance is write up a report on the advantages of such a cascaded system in an effort to justify adding the secondary instrument to aid the control valve.

In the governor problem there exists a secondary instrument, the hydraulic speed control circuit, and it should cost little to take advantage of the proper tie-in of the primary instrument output. Here the instrument engineer is not having to initiate the cost of the secondary instrument.

The conclusions drawn up in the six points listed under the heading "Advantages of an Ideal Governor" are those one gains by cascading or pneumatic setting the speed governor. The speed control (flyball) is an existing instrument which the author feels should not be retired to pre-emergency work but kept in continuous service so that these real advantages listed previously are made available in the ideal governor as result of cascading the primary instrument with speed controller.

The author has, since 1943, studied installations of many types of various horsepower units built by four or five American manufacturers. While some difficulty has been experienced on occasions, it has not been necessary to rebuild, redesign or even replace a major part of a Hydraulic Unit to get satisfactory operation both for manual and/or pneumatic operation.

It should be borne in mind that engineers are dreamers and sometimes the economics do not justify the maximum expenditure for a given piece of equipment. Many of us Instrument Engineers would like to own a 16-cylinder automobile and could no doubt write a longer paper than this one giving all its points of superiority; but most of us are satisfied to use a 6 or 8-cylinder car at a lower price, as a means of transportation.

Terminology Chart — Interpretation

TERM	INSTRUMENT ENGR.	STEAM ENGR. OR USER	MANUFACTURER
Regulation	Control Band Sensitivity Throttling Range	Per cent Fall Off in Speed due to loading. Speed gradient or droop.	Per cent rise in speed (on a gradual change) from full load to no load. (Usually 2 to 8%)
Turn-down	———	Variable Speed Operation	Ratio of rated normal speed to minimum speed required.
Hydraulic	Hydraulic Power	Oil power operated steam valve	Requires Hydraulic Unit and in some cases also steam balanced or powered single seated steam valve.
Relay	Operator of Hydraulic Servomotor	Part of Hydraulic Unit	Anything that squirts oil except to bearings.
Isochronous	Proportional plus reset type	Constant speed under all loads.	Equipped with regulation eliminator to give zero regulation.
———	Derivative action	———	Will not discuss as such but may build such into his basic design.
———	Reset rate adjuster	———	Stability adjuster on Isochronous type only.
Constant speed	Might expect proportional reset type	Low speed gradient with one operating load or constant duty.	Would normally build in flyball unit if manual turn-down ratio asked for is not excessive, or use flyball unit as pre-emergency when operated by pneumatic impulse.
Variable Speed Medium Regulation (8%)	Wide turn-down with wide (8%) throttling range or proportional band.	Wide speed range for varying load duty, with fair regulation.	Flyball type can be replaced by orifice type if regulation asked for is not 4% or less in order to reduce cost.
Variable Speed with close regulation (4% or better)	Wide turn-down with narrow proportional band.	Wide speed range, varying load operation, close regulation important.	Requires wide range flyball type unit continuously operated by manual speed changer and/or pneumatic impulse.

Section Secretaries, Meeting Data and Programs

AKRON
Russell F. Marquardt, 1782 Tonawanda Ave., Akron 5, Ohio. Tel: ST-6865
Fourth Tuesday, Meeting 8:15 P.M., Ayer Hall, U. of Akron.

ALBUQUERQUE
W. E. Bostwick, 2615 Sandia Dr., Bel Air, Albuquerque, N. Mex.
First Monday, Meeting at 8:00 P.M., Science Lecture Hall, Univ. of N. M.

ARUBA
J. L. Lopez P. O. Box 203, c/o Lago Oil & Transport Co. Ltd., Aruba, N. W. I. Tel. 2087.
First Tuesday, 7:30 P. M., Engr's Club.

ATLANTA
M. Virgil Davis, 357 Sixth St., N.W. Atlanta, Ga. Tel. EM. 3042
Fourth Friday, Meeting 7:30 P.M., Electric Bldg., Georgia Power Co.

BALTIMORE
G. B. Greer, 631 East 36th St., Baltimore 18, Md. Tel: CHesapeake 6879
Second Friday, Meeting at 8:00 P.M., Engr's. Club of Baltimore.

BATON ROUGE
John Q. Bass, 1571 Longwood Dr., Baton Rouge, La. Tel: 3-0283
Meeting monthly, L.S.U. Physics Bldg.

BOSTON
Stephen E. Lord, 60 Braintree Ave., Quincy 69, Mass. Tel: MA 9-1066
Fourth Wednesday, Dinner at 6:30 P. M., Meeting at 7:30 P. M., 99 Club, 99 State St.

CALIFORNIA
D. C. Duncan, Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif. Tel: SY 4-8439
Second Wednesday. Dinner at 6:30 P. M. Meeting at 8:00 P. M., Carolina Pines, 7315 Melrose Ave., Los Angeles

CENTRAL ILLINOIS
H. R. Getz, 723 Laura Ave., Peoria 5, Ill. Tel: 4-2800
First Wednesday, Dinner at 6:30 P.M., Meeting at 7:30 P.M.

CENTRAL INDIANA
Richard F. Rieman, 3550 Euclid St., Indianapolis, Ind. Tel. CH 7462
First Tuesday, Meeting at 7:30 P. M.

CENTRAL NEW YORK
H. G. Murray, 169 Durston Ave., Syracuse 6, N. Y. Tel: 9-9259
Third Monday, Dinner at 6:00 P. M., Meeting at 8:00 P. M.

CHARLESTON
D. A. Cunningham, 5140 Washington Ave., S.E., Charleston, W. Va.
First Monday, Dinner at 6:15 P.M., Meeting at 8:00 P.M., Kanawha Hotel.

CHICAGO
Floyd E. Ertsman, Rm. 1420, Fisher Bldg., 343 S. Dearborn St., Chicago 4, Ill. Tel: WE 9-0686
First Monday, Dinner at 6:30 P. M., Meeting at 8:00 P.M., Hotel Shoreland.
Feb. 4, Subject: Research vs. Industrial Instrumentation. Sponsored by Committee on Research Development.
Mar. 3, Subject: Analysis Instrumentation. Sponsored by Committee on Analysis.

CHINA LAKE
A. H. Staud, 1004 Michelson Lab., USNOTS, China Lake, Calif. Tel: 77882
Fourth Thursday, Meeting at 8:00 P.M., Michelson Lab, USNOTS.

CINCINNATI
R. J. Eichner, 1900 Courtland Ave., Norwood 12, Ohio. Tel: Jefferson 3130
Second Monday, Dinner at 6:30 P.M., Meeting 8:00 P.M., Engineering Soc. of Cinn.

CLEVELAND
G. D. Carnegie, 3436 Lorain Ave., Cleveland, Ohio.
Second Wednesday, Dinner at 6:30 P. M., Meeting at 8:00 P.M., Cleveland Eng'r. Society, 2136 E. 19th St.

COLUMBUS
E. M. Chandler, 91 E. Como Ave., Columbus 2, Ohio. Tel: JE 9994.
Third Thursday, Meeting at 8:00 P.M., Battelle Auditorium

CUMBERLAND
Clyde Babst, 225 Cecelia St., Cumberland, Md. Tel: 583-W
Fourth Wednesday, Dinner at 6:30 P. M., Meeting at 8:00 P. M., Alighan Shrine Country Club, Baltimore Pike.

DENVER
G. M. Peters, 3191 W. Denver Place, Denver 11, Colo. Tel: GRand 9073

DETROIT
Frank R. Davis, Edison Institute, Dearborn, Mich. Tel: LO 1-1620 Ext. 5517
Third Tuesday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., Rackham Bldg.

EASTERN NEW YORK
Robert W. Carter, Sterling-Winthrop Research Institute, Rensselaer, N. Y. Tel. Albany 5-6251 Ext. 262
First Tuesday, Meeting at 8:00 P.M., Siena College, Loudonville, N. Y. Optional Dinner at 6:00 P.M., Circle Inn, Lathams, N. Y.

GULF COAST
W. N. Sloan, E. I. Du Pont de Nemours & Co., Orange, Texas. Tel: 8411 Ext. 444
Third Tuesday. Meeting at 7:30 P.M., Lamar College, Beaumont, Texas.

HOUSTON
I. K. Farley, Brown Instrument Co., 2123 Travis St., Houston, Texas, Tel: Charter 2511.
Last Monday, Meeting at 8:00 P.M., University of Houston Library Building.

KANSAS CITY
J. C. Brous, 8827 Maiden Lane, Kansas City 5, Mo.
First Tuesday, Meeting at 7:30 P.M., U. of Kansas City, Science Bldg., Rm. 106.
Feb. 5, Subject: Electronic Instrumentation. Speaker: Nelson Gildersleeve, General Electric Co.
Mar. 4, Subject: Pneumatic versus Electronic Controls for Pipeline and Booster Stations. Speaker: S. S. Smith, Shell Pipe Line Co.

LOUISVILLE
C. M. Bosworth, 203 Arbor Park, N., Lo., Ky.
Fourth Tuesday, Meeting at 8:00 P.M., Seagram Auditorium.

MONTREAL
L. E. Henne, Bristol Co. of Canada Ltd., 712 Dominion Square Bldg., Montreal, Quebec, Canada Tel: UNiversity 6-4725.
Last Monday, 8:00 P.M., Mechanic's Institute.

NEW JERSEY
L. H. Ballinger, 2371 Channing Ave., Westfield, N. J. Tel: Westfield 2-0765M
First Tuesday. Meeting at 8:00 P.M., Essex House, Newark.

NEW ORLEANS
W. H. Haney, 2927 Music St., N. O. 22, La.
No Regular Date, Meeting at 8:00 P.M.

NEW YORK
F. B. Leslie, 8856 Commonwealth Blvd., Bellerose 6, N. Y. Tel: FI 7-0645
Last Monday, Dinner at 6:00 P.M., Meeting at 7:45 P. M., Hob Nob Club, 108 E. 41st St.
Jan. 28. Subject: Instrumentation Problems on the Aramco Oil Pipe Line. Speaker: Fred Rich. A color film will be shown of the construction of this line in Saudi Arabia.
Feb. 7-8, Fifth Annual Regional Conference. Hotel Statler, New York, Subject: Power Plant Instrumentation.

NIAGARA FRONTIER
Mrs. James L. Martin, 34 Manning Rd., Eggertsville 21, N. Y. Tel: WIndsor 0087
Fourth Monday, Dinner at 6:30 P.M., Meeting at 8:00 P.M., N. Y. State Inst. of Arts and Sciences, Buffalo.

NORTH TEXAS
R. E. Byers, 6000 Lemmon Ave., Dallas 9.

NORTHERN CALIFORNIA
Burt L. Anderson, 1951 47th Ave., San Francisco 16, Calif. Tel: SEabright 1-5030
Third Monday, Dinner 6:30 P. M., Meeting 8:00 P.M., Spengers Grotto, 1919-4th St., Berkeley.

NORTHERN INDIANA
J. Baum Beckman, 7145 Wicker Ave., Hammond, Ind. Second Tuesday, Meeting at 7:30 P.M., Whiting Community Center, Whiting, Ind.
Feb. 12, Subject: Basic Television Receivers. Speaker: Joe Rudman, United States Steel Corp.
Mar. 11, Subject: Television in Industry. Speaker: G. H. Wilson, Diamond Power Specialties Co.

OAK RIDGE
J. Lundholm, Jr., Eff. A-3, Apt. 214, Oak Ridge, Tenn. Tel: 5-6539
First Wednesday, Meeting at 7:30 P.M., Knight's of Columbus Hall.

ONTARIO
John W. Huether, 311 Southerland Dr., Leaside, Ontario, Canada. Tel: HU-7114
Third Thursday, Meeting at 8:00 P.M. Friendship Hall, College St. United Church, Toronto

PANHANDLE
Bruno F. Loewen, Philips Chem. Co., Box 1526, Borger, Texas.
Third Tuesday, Meeting at 8:00 P.M.

PERMIAN BASIN
J. B. Jenkins, 509 South Ave. "C," Kermit, Texas.

PHILADELPHIA
R. A. Trenner, Energy Control Co. Rm. 306, 3147 N. Broad St., Philadelphia 32, Pa. Tel: SA 2-7900
Third Wednesday, Meeting at 8:00 P.M., Bellevue-Stratford Hotel.

PITTSBURGH
W. C. Langerman, Fisher Scientific Co., 711 Forbes St., Pittsburgh 19, Pa. Tel. Express 1-1330.
Fourth Monday, meeting jointly with the Technical Committee on Inspection and Gaging. Dinner at 6:30 P.M., Meetings at 8:00 P.M., Roosevelt Hotel.

PRESQUE ISLE
Edwin P. Schuwerk, 445½ Halley St., L. P., Erie, Pa. Tel: 2-3349
Fourth Tuesday, Meeting at 8:00 P.M., G. E. Community Center, East Lake Rd., Erie, Pa.
Jan. 22. Subject: Measurement & Control of Pressure. Speaker from The Bristol Co.
Feb. 26, Subject: Measurement and Control of Temperature. Speaker: from Brown Instrument Co.

RICHLAND
T. H. Quinn, 1513 Goethals Dr., Richland, Wash. Tel: 7-8717
Second Wednesday, Meeting at 7:30 P.M., American Legion Hall.

ROCHESTER
R. C. Schwarz, Jr., 1201 Granite Bldg., Rochester 4, N. Y. Tel: Monroe 4610R
Fourth Tuesday, Meeting at 8:00 P.M., Univ. of Rochester, Physics Lecture Hall.

SARNIA
L. J. Hall, 730 Talfourd St., Sarnia, Ont., Canada. Tel: EDgewater 2258.
Second Monday, 8:00 P.M., Moose Hall.

SOUTH TEXAS
H. C. Givens, La Gloria Corp., P.O. 637, Falfurrias, Texas. Tel: 122-W
First Wednesday. Meeting at 7:30 P.M.

SOUTHERN MICHIGAN
Lyle J. Draper, 2233 Oakland Dr., Kalamazoo, Mich.
Fourth Wednesday, 8:00 P. M., Dinner at 6:30 P. M., Chicken Charlie's, Kalamazoo.

ST. LOUIS
W. G. Lee, 4710 Delor St., St. Louis 16, Mo. Tel: FL 8516.
First Wednesday After First Monday, Meeting at 8:00 P.M., Engineer's Club of St. Louis.
Feb. 6, Subject: Electronic Instrumentation. Speaker: Nelson Gildersleeve, GE.
Mar. 5, Subject: Pneumatic versus Electronic Controls for Pipeline and Booster Stations. Speaker: S. S. Smith, Shell Pipe Line Co.

TOLEDO
P. H. Girkins, 418 Waggoner Blvd., Toledo 12, Ohio. Tel: LA 6505
Third Tuesday, Meeting at 8:00 P. M., Service Bldg., Toledo Edison Co.

TENNESSEE
James L. Williams, 2237 Bruce St. Kingsport, Tenn. Tel: 2079-L
Fourth Thursday, Civic Auditorium.

TULSA
S. M. Bagwell, 1544 E. 35th Pl., Tulsa 5, Okla. Tel: 7-6822
First Monday, Meeting at 7:30 P.M., Engineering Bldg., Tulsa Univ.
Feb. 4, Subject: Electronic Instrumentation. Speaker: Nelson Gildersleeve, GE.
Mar. 3, Subject: Pneumatic versus Electronic Controls for Pipeline and Booster Stations. Speaker: S. S. Smith, Shell Pipe Line Co.

TWIN CITIES
Jerome J. Schwab, Engineering Sales, 516 Guardian Bldg., St. Paul 1, Minn. Tel: GArfield 0601
Fourth Tuesday, Dinner at 6:30 P.M., Meeting 7:30 P.M., Rm. 353, Coffman Memorial Union, U. of Minn.

WASHINGTON
Raymond E. Miller, 1-205 Naval Ord. Lab., White Oak, Md. Tel: JU 7-6742
Third Monday, Meeting at 8:00 P.M., P. E. P. Co. Auditorium.

WAYNE COUNTY
J. R. McCauley, 18073 Archdale, Detroit 19, Mich. Tel: KE 1-5239.
Third Monday, Meeting at 8:00 P.M., Larson's Cafe, Lincoln Park, Mich.

WILMINGTON
J. E. Charsha, Jr., Hammel-Dahl Co., 1000 Washington St., Wilmington 11, Del. Tel: 2-6694
Third Tuesday, Meeting at 8:00 P.M. Harlan Public School, Wilm.

Cleveland Show Gets Under Way

The Exhibit Allocations Committee made up of E. C. Baran (Standard Oil Co. of Ohio) representing the Oil Industry; R. J. Carleton (Republic Steel Co.) the Steel Industry; and R. E. Pritz (E. I. du Pont de Nemours & Co.) the Chemical Industry met in the office of Fred A. Lennon, President, Crawford Fitting Co., at 9:30 A.M., December 15th.

These men attended the meeting under very unfavorable weather conditions (Cleveland had a 14 inch snow-

Cars parked outside of the office of Crawford Fittings during the Allocations Committee meeting.

fall with a low temperature of 5 degrees), and the Society and Exhibit are very much indebted to the members of the Committee for a job well done. In addition to the Committee the following were present: Robert Newton, (Manufacturers Representative); Fred Lennon, Chairman of the Cleveland Host Committee, and Richard Rimbach, Exhibit Manager.

134 booths were allocated to 75 exhibitors who sent in their reservations during the 30 day option period granted to all exhibitors who had exhibited at the Houston or Buffalo Exhibits. Booth assignments were also made to 11 companies, which wrote in for space but did not have the 30 day option.

The allocations and assignments were as follows:

EXHIBITORS

Acragage Co.
American Meter Co.
Annin Co.
Askania Regulator Co.
Assembly Products, Inc.
Bacharach Industrial Instrument Co.
Barton Instrument Co.
Beckman Instruments Inc.
J. Bishop & Co.
Black, Sivalls & Bryson Inc.
Bowser, Inc.
Brooks Rotameter Co.
Burgess Battery Co.
Century Geophysical Corp.
Conoflow Corp.
Consolidated Engineering Co.
Continental Equipment Co.
Crawford Fitting Co.
Daniel Orifice Fitting Co.
Daven Co.
Davis Emergency Equipment Co.
DeZurik Shower Co.
Eagle Signal Co.
Edin Co.
Farris Engineering Co.
Fenwal Inc.
Fischer & Porter Co.
Fisher Governor Co.
Fulton Sylphon Div.
General Electric Co.
Gow Mac Instrument Co.
Hammel Dahl Co.
A. W. Haydon Co.
Hays Corp.
Imperial Brass Mfg. Co.
Industrial Instruments Corp.
Industrial Instruments, Inc.
Industrial Pyrometer & Supply Co.
Instruments Publishing Co.
J. B. T. Instruments Inc.
Kieley & Mueller Inc.
Lapp Insulator, Inc.
Leslie Co.
Librascope, Inc.
Magnetrol, Inc.
Marine & Industrial Products Co.
Mason-Neilan Regulator Co.
Meriam Instrument Co.
Milton Roy Co.
Mine Safety Appliances Co.
Mittlemann Electronics Div.
Samuel Moore & Co.
Nash Engineering Co.
New Hermes Engraving Mach. Co.
North American Philips Co.
Palmer Thermometers Inc.
Panellit Inc.
Parker Appliance Co.
Perkin Elmer Corp.
Photoswitch Inc.
Physicists Research Co.
Potter Aeronautical Co.
Proportioneers Inc.
Rockwell Mfg. Co.
R-S Products Corp.
Sanborn Co.
Southwestern Industrial Electronics Co.
Standard Electric Time Co.
Herman H. Sticht Co.
Superior Electric Co.
Superior Tube Co.
Swartwout Co.
Telechron Inc.
Vapor Recovery Systems Co.
Veeder Root, Inc.
Wallace & Tiernan Products, Inc.
Weatherhead Co.
Wm. Welch Mfg. Co.
Wheelco Instruments Co.

As only 165 booths were laid out at the Cleveland Auditorium and 150 were allocated or assigned before opening of the general sale of exhibit space it was decided to expand the number of booths to 273 by laying out additional space in the Exhibit Hall immediately below the Arena. The general sale of exhibit space started January 10th.

Rimbach Resigns Secretary Post

Richard Rimbach, First Executive Secretary of ISA, who has served the Society in that capacity continuously since April 28, 1945, tendered his resignation to the Executive Committee during its meeting on December 2, 1951. This action on the part of Mr. Rimbach was not entirely unexpected. For some time he has realized that the job of running the National Office had become too time consuming to handle on a part-time basis.

He offered his resignation to the Committee in September, but was persuaded to reconsider at that time. At the December meeting, however, Mr. Rimbach expressed the opinion that your new Manager is now capable of taking over all of the duties and responsibilities of the National Office and insisted that his resignation be accepted effective December 8, 1951.

Mr. Rimbach's resignation was regretfully accepted with an expression of deep appreciation for his untiring work during his years of service as Executive Secretary of ISA. Mr. Rimbach will continue as Exhibit Manager of the Society and will always be available for such other ISA duties as his time permits.

R. RIMBACH

PORTER HART

Hart Named ISA Secretary

Porter Hart, First Vice-President of ISA during 1951, was appointed by the Executive Committee to serve as National Secretary until his successor is elected by the Council and takes office.

Instruments Publishing Co. First ISA Corporate Member

That "Dick" Rimbach's resignation as Executive Secretary of ISA does not mean a loss of interest in the Society or its activities is strongly evidenced by the following letter received by the National Office on December 12, 1951:

The Instrument Society of America
Allegheny and Pennsylvania Avenues
N. S., Pittsburgh, Pa.

Gentlemen:

With the establishment of Corporate Membership by the Instrument Society of America, the Instruments Publishing Company applies for such membership as No. 1 corporate member, and you will find attached hereto a check for $250.

This is in line with our desire to cooperate in the development and promotion of the Society as was indicated by our donation of $1000 immediately after its organization.

Sincerely yours,
INSTRUMENTS PUBLISHING COMPANY
Richard Rimbach
Publisher

ISA's 1951 President McMahon made the following comment in respect to the above: "I . . . feel that it is highly appropriate that the first election to membership in this grade should be to this company, whose publisher has done so much both personally and in his capacity as publisher to forward the interest of the Society."

We are sure that this feeling is one that is shared by the many ISA members who have known Dick Rimbach as "Mr. Instruments."

G. E. Greiner

It is with deep regret that the Tulsa Section announces the death of one of its members, G. E. Greiner. Mr. Greiner joined the Tulsa Section November 1947.

Francis B. Wilcox

The Cincinnati Section announces with regret the death on November 1, 1951 of one of its leading members, Francis B. Wilcox. One of the founders of the Cincinnati Section, Mr. Wilcox was its Vice-President at the time of his death.

ISA
EMPLOYMENT SERVICE
Forward your letter to INSTRUMENT SOCIETY OF AMERICA
921 *Ridge Ave., Pittsburgh* 12, *Pa.*

ELECTRONICS ENGINEER. Must have background of extensive experience and interest in the field of electronic design. Duties would primarily involve design of circuits for aircraft instrumentation. From 4-7 years of actual experience with additional graduate work is desired. Location Buffalo, N. Y., Box 617

ELECTRONICS ENGINEERS (3). To be responsible for investigation and development of varied and occasionally complex phases of prcject in electronics or electro-mechanics. Must be capable of design, construction, test, and operation of breadboard and pilot model devices. Must be able to prepare and edit full reports, coordinating the reports of other engineers working in the same project. Location Buffalo, N. Y. Box 618

ELECTRO-MECHANICAL ENGINEER. For development of Solenoid operated thermostatic devices and for development and design work in

the instrument field. Location Philadelphia, Pa., Box 619

ENGINEER. One who has shown ingenuity in the field of small electro-mechanical devices, switches, relays, and the like, and who is able to analyze the electronic circuits in which they are used. For position of Assistant Chief Engineer. Formal education not important but ingenuity is. Location Boston, Mass., Box 620

SALES ENGINEER. For long established manufacturer of flow meters and full line of air operated controls for temperature, pressure, level, and flow, required for specialized field work leading to position of Sales Manager. Salary open. Reply in confidence. Location Philadelphia, Pa., Box 621

GOVERNMENT SERVICES

To apply for any of the following Federal Agency positions, write direct to the Agency holding the position, for official application form.

U. S. Naval Ordnance Test Station, Inyokern, California

Design and development of electronic instruments for use in free flight ballistics experiments in Fin-Stabilized rockets. $5060 per annum.

Application of new theories in the field of automatic control and instrumentation. Desiré extensive knowledge of servomechanisms. $5940 per annum.

Design engineer for power transmissions and distribution and detail of instrumentation facilities for ground ranges. $5060 per annum.

Trainee positions in electrical engineering. Students who expect to receive a degree in electrical engineering in mid-year are invited to file as well as individuals who are immediately available. $3410—$4205 per annum.

Theoretical design and development of specialized photographic and optical equipment and instrumentation. $5940 per annum.

U. S. Naval Air Missile Test Center, Point Mugu, California

Test and evaluate missile automatic stabilization and control devices and instruments in laboratory to determine operating characteristics and ability to meet design specifications. Analysis of servomechanism systems. $5060 per annum.

Head of Air Frames Test Branch; supervise formulation of test plans and instrumentation requirements. Determine desirability of developing experimental test vehicles and/or specialized instrumentation. Provide consulting services for other divisions and contractors on testing, design, and instrumentation of scale model guided missiles and their components. $7040 per annum.

Corona Laboratories, National Bureau of Standards, Corona, California

20 Research design and development work in (1) instrumentation for ground and flight testing of guided missiles, (2) microwave circuitry and antenna systems, or (3) determination of complex missile systems. (requires knowledge of ballistics, aerodynamics, and/or hydro-dynamics) $3410-$9600 per annum. Salary will depend on qualifications.

3 Infrared radiant energy measurement and utilization; basic study of properties of infrared sensitive detectors and related instrumentation. Duties of position can be varied to fit qualifications of applicants. Electronic specialization primary requirement with knowledge of optics, quantum mechanics, radiometry, spectroscopy, or solid state physics desirable. PhD in physics desirable for higher salary levels. $5060-$7040 per annum.

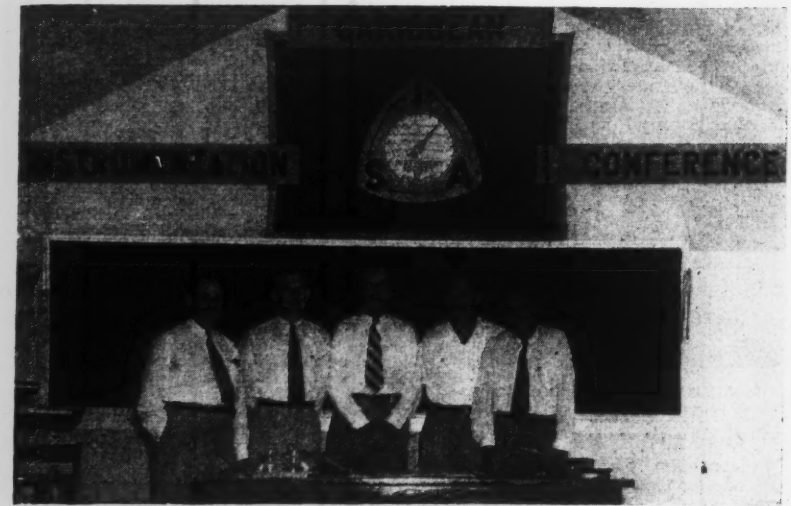
Caribbean Instrumentation Conference

A successful Instrumentation Conference was conducted by the Aruba Section on November 15th and 16th, 1951. The technical sessions were supplemented by a series of tours for the off-island visitors which included plant tours, lectures, and plant demonstrations.

The Sixth Annual Meeting and Banquet was highlighted by the installation of officers for the coming year. A special skit, entitled, "The Face on the Barroom Floor," and dancing followed.

Attendance at the Technical Sessions numbered 65 on Thursday and 50 on Friday, while 46 attended the Banquet.

Papers presented included: "Electronics," by H. M. Schmitt, Brown Instruments Div., Minneapolis-Honeywell Regulator Co.; "Automatic Control of a Group of Boilers," by J. J. Lowey-Ball, Curacaosche Petroleum Industrie, Maatschappij—Curacao, N. W. I.; "Graphic Panels," by R. Schlegel, Brown Instruments Div.; "Graphic Panels," by V. Tivy, The Foxboro Company; and "The Development of an Instrument Job Training Program," by P. E. Jensen, Lago Oil & Transport Co., Ltd.



Technical sessions speakers (left to right): H. M. Schmitt, V. V. Tivy, R. A. Schlegel, P. E. Jensen, J. J. Lowey-Ball.

BOOK REVIEWS

Phase Microscopy

By A. H. Bennett, H. Jupnik, H. Osterberg, and O. W. Richards

320 + xiii pages, amply illustrated. Published by John Wiley and Sons, Inc., 1951. $7.50.

Phase microscopy makes possible the microscopy of transparent materials of low contrast. The four authors, of the Research Laboratory of the American Optical Co., have produced a book that covers principles and practical uses. The principles are covered in elementary nontechnical style, with the mathematics of the diffraction theory covered in the appendix. All practical factors are covered in chapters on instrumentation, technics, biology and medicine, and industrial application.

Methods of Operations Research

By Philip M. Morse and George E. Kimball

158 pages, amply illustrated, cloth bound. John Wiley & Sons, Inc., 1951. $4.00.

The object of operations research is to find all the sensitive parameters that affect a given operation, and to evaluate these parameters for optimum results. The technique makes use of statistical analysis, analytical methods, and operational experience. This book, the first unclassified book on the subject, uses many military examples. It defines the science, states the boundaries of usefulness, explains the tools to be used, presents several military applications, and discusses the setup of an operations research group.

Practical Electron Microscopy

By V. E. Cosslett

299 pages, 147 illustrations. Academic Press Inc., 125 E. 23rd St., N. Y. 10, N. Y. $5.50.

Several hundred electron microscopes are now in use. This book covers both the principles and operation of practical electron microscopes. The physical principles are explored clearly and with minimum use of mathematics. The construction of all types of electron microscopes is explained in detail. Great emphasis is placed on operational factors which can enable one who uses the electron microscope to obtain optimum results. Two chapters are devoted to specimen techniques. The level is essentially non-mathematical although it is assumed the reader has some background in physics, particularly optics.

Experimental Spectroscopy (Second Edition)

By Ralph A. Sayer

Prentice-Hall, Inc., New York, 1951. Cloth, 6½ x 9¼ in., 358 pages. Price $6.65.

The purpose of this book is to discuss prism and grating spectrographs and the techniques of their use in research. It is designed for students of spectroscopy and for those in research laboratories who wish to make use of spectroscopic procedures. Extensive mathematical treatments have been avoided; a background of general physics and some physical optics should be sufficient for an understanding of the presentation.

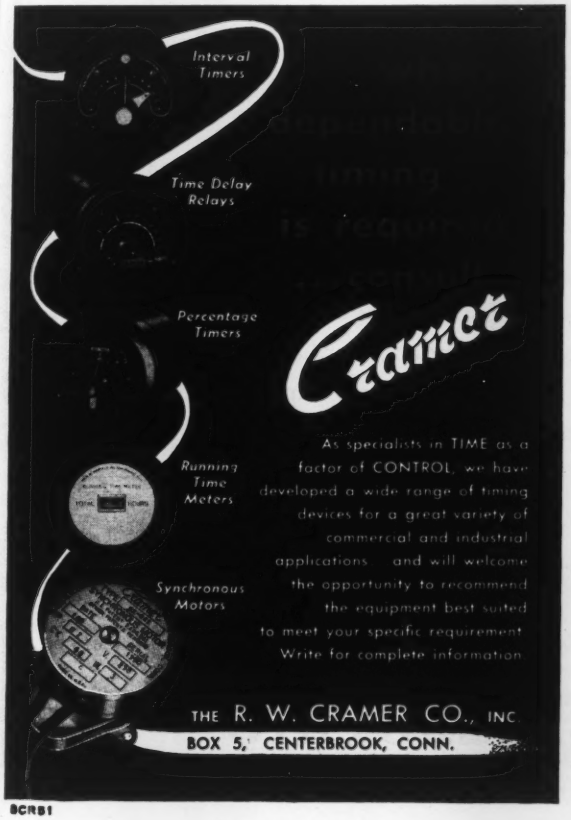
INSTRUMENT MERCURY

★ Purified specifically for *Instrument* use.
★ Meets not only *standard chemical*, but also more *exacting physical tests.*
★ Delivered in a handy bottle with *dispensing tip.*
★ Controlled filling without exposure to contamination.
★ Stays bright and clean in long storage.
★ Premium quality without premium price.

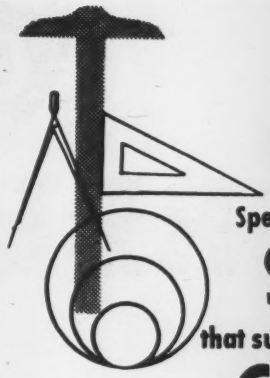
Write for current quotations

Bethlehem Apparatus Co., Inc.

887 Front St. • Hellertown, Pa.


Interval Timers
Time Delay Relays
Percentage Timers
Running Time Meters
Synchronous Motors
Cramer
As specialists in TIME as a factor of CONTROL, we have developed a wide range of timing devices for a great variety of commercial and industrial applications and will welcome the opportunity to recommend the equipment best suited to meet your specific requirement. Write for complete information.
THE R. W. CRAMER CO., INC.
BOX 5, CENTERBROOK, CONN.

BCRB1



ENGINEERS

Special opportunities for YOU in

SAN DIEGO

that sunshiny, smog-free city on the coast of

CALIFORNIA

Convair (Consolidated Vultee Aircraft Corporation) is now accepting applications for these following positions in its modern, progressive Engineering Department.

Design Engineers	**Weight Engineers**
Design Draftsmen	**Aerodynamics Engineers**
Electrical Draftsmen	**Test Engineers**
Electronics Engineers	**Thermodynamics Engineers**
Microwave Engineers	**Aircraft Loftsmen**
Servo Engineers	**Aircraft Linesmen**

WORKING FACTS: You get two holidays a week at Convair — overtime accomplished in 5-day week. Attractive salary ranges. An "engineers" engineering department . . . with stimulating, competent associates . . . and interesting, challenging, essential, long-range projects of a wide variety including — commercial aircraft, military aircraft, missiles, engineering research and electronic development. Excellent patent royalty arrangements. Top-notch retirement plan — better than-average life and health insurance. Complete progress-salary review for each person twice yearly. Opportunity for continuing engineering education.

LIVING FACTS: San Diego, with its wonderful residential areas, offers you and your family incomparable living. Ideal climate — cool, clean, dry. Mountains, desert, Mexico, Hollywood, Los Angeles, Pacific Ocean, beaches and bay — only hours or minutes away. It offers you a new way of Life... pleasant, refreshing, happy.

If you qualify, you will receive generous travel allowances.
***SEND COUPON* for free booklets and complete information.**

THANK YOU

Mr. H. T. Brooks, *Engineering Department* 90
***Convair,* 3302 Pacific Hiway, San Diego, California**

Please send me ***FREE*** booklets describing the Convair Opportunity for me and my Convair Application Form.

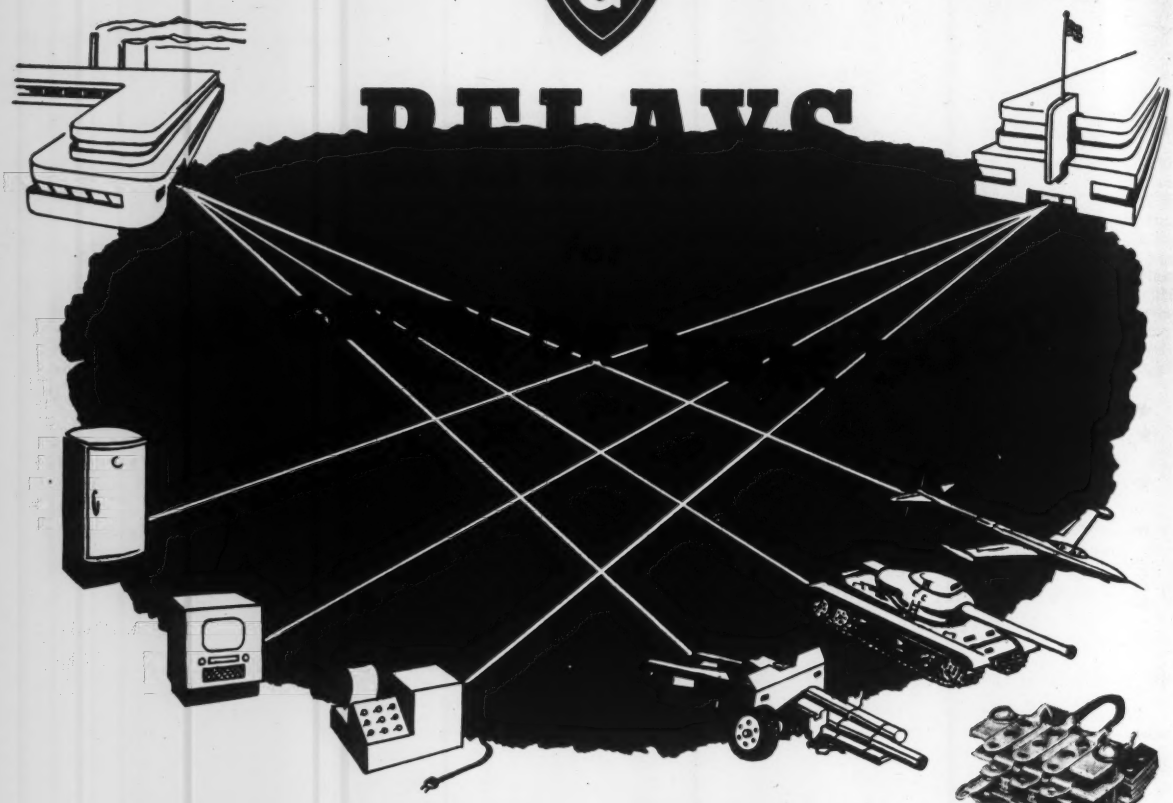
My name _____

Occupation _____

Address _____

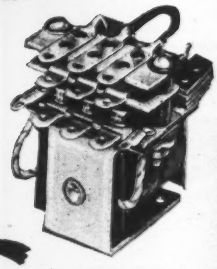
City _____ State _____

RELAYS



IN QUALITY PRODUCTS EVERYWHERE . . .

GUARDIAN *Controls*



Series 345 D.C. Relay
Hermetically Sealed or
with Open-Type Mounting

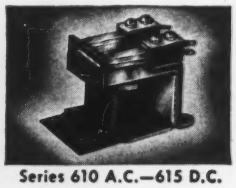
As real as rockets, guided missiles and supersonic jets are the Guardian Controls that set them off and direct their flight. Guardian relays—stepping switches—contactor units—solenoids—multi-contact switches are the basic components of communications, bombing and firing equipment, of control stick switches, control wheels and myriad Guardian developments for the military. Certain basic Guardian control components are still available for peacetime products. Write.

A.N. Connector Plug
Hermetic Seal Container

AN-3320-1 D.C.

AN-3324-1 D.C.

Series 595 D.C.



Series 610 A.C.—615 D.C.

Series 695 D.C.

Get Guardian's New HERMETICALLY SEALED RELAY CATALOG Now!

GUARDIAN ELECTRIC

1638-A W. WALNUT STREET CHICAGO 12, ILLINOIS

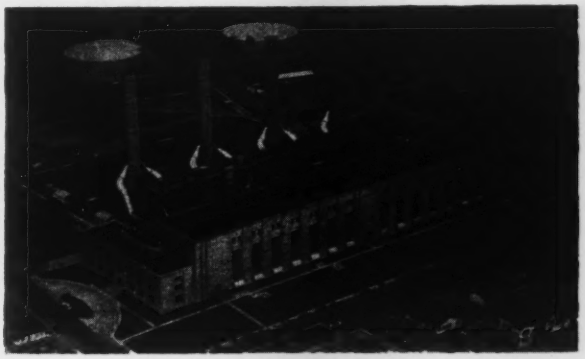
A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

JOURNAL of the
Southern California Meter Association

President: H. C. Bennett
Vice-President: F. M. Partridge
Secretary-Treasurer: Geo. H. Forster, Jr., 2916 Eucalyptus Ave., Long Beach 6, Calif.
Auditor: C. B. McKinney
Past President: James E. Adams

Operating Experiences with Multi-element Control

By HOWARD L. ANDERSEN
Southern California Edison Co.



Air view of Southern California Edison Company's $38,500,000 Redondo Steam Station. Provisions for use of oil, gas, or coal for fuel, and extensive use of outdoor equipment have been made. Total generating capacity is 288,000 kilowatts.

Multi-element controllers measure and combine several inter-related variables to control a process function within close limits, over wide load changes, and with high stability.

Multi-element Control

A CONTROL "element" can be defined as a measuring device which senses a changing condition in a controlled process and converts the measurement to a controlling force. A single-element controller measures one changing condition and usually controls one function of the process. A multi-element controller measures two or more changing conditions and combines the resulting forces to control one or more functions of the process.

Single-element controllers sometimes are used to control several functions in parallel. Also, two or more single-element controllers are used at times in a series arrangement, each element measuring a single condition and controlling one function. These are not multi-element systems.

A Simple Analogy

A multi-element controller has advantages in any process requiring close limits of regulation, high quality of product, or good stability through wide ranges of quantity and time. This can be understood best by using a simple analogy.

Consider the problem of maintaining a liquid level in a tank of limited storage capacity (Fig. 1). The uncontrolled variables are the rate of discharge from the tank, and the supply pressure of the liquid input to the tank. The control problem is to maintain the level in the tank within close limits.

To appreciate the difficulty of the control problem, let us mentally operate the hand valve in the supply pipe to the tank. We have no knowledge of the flow demand at the discharge, and no knowledge of the changes in supply pressure which may occur. As we have only a gage glass to indicate tank level, this is a single-element controller. When severe changes occur in the supply and discharge, we will probably find it impossible to maintain an acceptable level.

Now let us add two measuring elements (Fig. 2) which can "sense" the changes occuring in the supply and discharge pipes. Each of these elements can measure quantity and time, and indicate the quotient as a *rate* of flow. To assist us in making a rapid and accurate comparison of the two flows, let us superimpose one indicator over the other, as shown in Fig. 2.

Let us again man the valve. We now need only to hold the indicators together. As long as we match the inlet flow, which we are controlling, to the uncontrolled discharge flow, our level is automatically maintained. An occasional glance at the gage glass to correct for slight inaccuracies of measurement is all that is necessary. This three-element measurement enables us

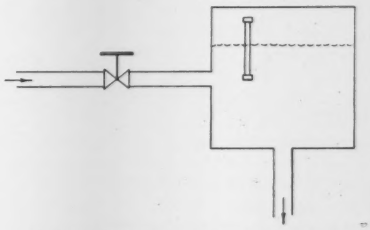


Fig. 1. Single-element control of liquid level.

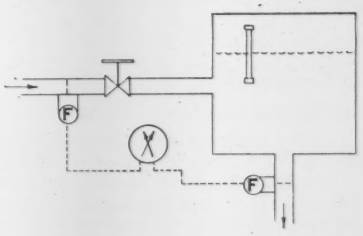


Fig. 2. Elements added to measure and indicate the rate of flow at inlet and outlet.

Presented at a regular meeting of the Southern California Meter Association.

February Meeting: 25th annual (Silver Anniversary) High Jinks.

to make rapid adjustments of the valve to control the level closely.

Substituting Automatic Control

To complete our analogy, let us substitute an automatic single-element control system (Fig. 3) for the gage glass and hand valve shown in Fig. 1. The gage glass is replaced by a level-sensing element which measures a change in level and converts this measurement to a controlling force, which positions the valve. Refinements can be added between the measuring element and the control valve to partially offset the natural limitations of this type control. Such refinements can make the system entirely satisfactory for some requirements.

To conclude the comparison, let us now convert the supply flow measurement into a force which we combine differentially with another force developed by the measurement of the discharge flow (Fig. 4). Let us also modify the resulting force by one developed by a deviation from a preset level. Finally, let us use the modified force to position the valve, as shown in Fig. 4. We now have a basic multi-element control system consisting of three control elements which are coordinated to control a process function. In this manner, components of a multi-element control system can be set up in a variety of combinations to handle complex process functions.

Fig. 3. Single-element level-control system.

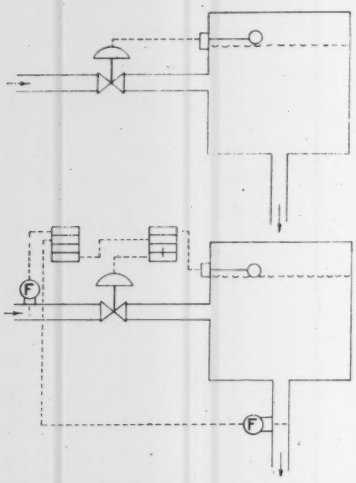


Fig. 4. Three-element control system.

Operating Experiences

Fuel-oil Temperature Control

Fig. 5 shows a system in which fuel oils, having a viscosity of 39 to 93 SSF at 122 deg. F., pass through a tube-and-shell-type heat-exchanger bank. Steam, supplied to the control valve at 200 psi. and 450 deg. F., furnishes the heat. The steam is desuperheated to 240 deg. F., and a shell pressure range of 0 to 15 psi. is maintained. The maximum flow of oil is 150 gpm. Minimum flow is about 60 gpm. when recirculating oil to keep the lines hot. Oil is supplied to the heaters at 125 deg. F. and is discharged at 200 deg. F.

The controller is a two-element type. It measures (1) steam pressure in the shell of the heater to provide a primary control force, and (2) fuel-oil temperature leaving the heater to provide a secondary, or modifying, control force. The final, or modified, force positions the steam supply valve.

The steam desuperheating controller is a single-element type which positions a water-spray supply valve by measuring the controlled steam temperature.

The temperature control on this system works satisfactorily on oil flows from 100 gpm. to maximum, but some difficulty has been experienced on extremely low flows. The difficulty might be caused by the necessarily large capacity of the heater for wide range demand.

Fig. 5. Two-element control of fuel-oil temperature in heat exchanger.

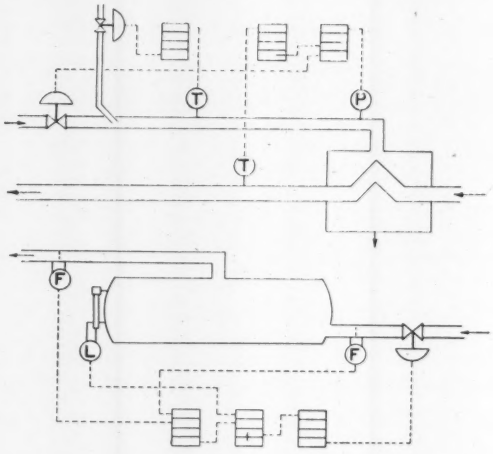


Fig. 6. System for controlling water level in boiler drum.

Boiler-drum Water-level Control.

Fig. 6 shows a system in which the water level in the boiler drum is controlled by feed-water flow-regulating valves. An approximate ten-inch differential in water level is maintained automatically through a steam flow range of 20,000 lbs./hr. to 400,000 lbs./hr. The controller is a three-element type, measuring steam flow from the boiler against feed-water flow to the boiler, and corrected by drum level.

This controller is being used on seven boilers generating steam at a maximum rate of 400,000 lbs./hr., a pressure of 1000 psi., and a temperature of 900 deg. F. Operating experience has proved it reliable to plus or minus 1-inch error over periods of months between calibration.

Large load swings have been experienced, and the average over-corrections in level have been not more than one inch. The response is sufficiently rapid to need no manual adjustment during full load swings.

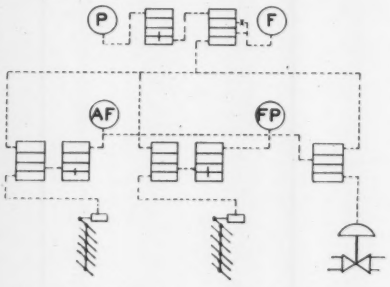


Fig. 7. Multi-element control system for boiler combustion.

Boiler Combustion Control.

Boiler combustion is controlled by the use of a multi-element control system (Fig. 7) which measures station steam header pressure, station steam flow, combustion air flow, fuel flow, and furnace pressure. The measurements are transposed into control forces which position forced and induced draft fan dampers, burner retractors, and fuel valves. The system automatically accepts a proportionate share of the station load and load changes, holds preset excess air values, and maintains a proper negative furnace pressure. The automatic controller handles all these conditions through a steam-flow load range of 20 to 1 (400,000 lbs./hr. to 20,000 lbs./hr.).

An example of the boiler-control response is the response to a recent sudden load loss of 125,000 kw.—from 280,000 to 155,000 kw. The steam header pressure increased from 875 to 910 psi. Seven boilers handled a reduction in total load of approximately 1,000,000 lbs./hr. steam flow without smoking or lifting a safety valve.

Instrument Maintenance Short Course

The recent Instrument Maintenance Short Course sponsored by the Southern California Meter Association and the Los Angeles Harbor Junior College was so successful that the Association and the College have determined to make the course an annual affair.

The Short Course was held afternoons and evenings on the campus of the Los Angeles Harbor Junior College on November 15th, 16th, and 17th. Twenty-three speakers presented meetings and panel discussions on subjects of interest to Instrument and Meter men. A typical meeting (Fig. 1) shows Mr. Frank Partridge of the Southern California Gas Company discussing *Fundamentals of Orifice Measurement*. Fig. 2 shows a portion of those attending dinner at the Los Angeles Harbor Junior College Dining Room. The dinner was held in connection with the evening meeting where Mr. J. C. Groenewegen of the Shell Chemical Company presented the *ABC's of Instrumentation*.

An exhibit of cut-away and operating instruments was made in the Los Angeles Harbor Junior College Laboratory. Thirty four companies prepared and presented exhibits. This exhibition was considered an outstanding success by both the exhibitors and those in attendance. Fig. 3 shows a portion of the instrument exhibit.

The registration for the three-day course was over 400, which was twice the number expected. The registrants represented nearly a hundred companies.

Fig. 1. (Top left) Frank Partridge of the Southern California Gas Company discusses "Fundamentals of Orifice Measurement" at a meeting of the Instrument Maintenance Short Course.

Fig. 2. (Bottom left) Dinner in the Junior College Dining Room.

Fig. 3. (Below) A portion of the instruments exhibited by instrument manufacturers.

Specify the Best!
PHILADELPHIA
THERMAL CONTROLS
AND THERMOMETERS
Our Leadership for nearly a half century is your assurance of complete satisfaction when you specify a "Philadelphia" instrument.
Steady, accurate and dependable performance is guaranteed.
Feel free to consult with our specialized staff on any problem in our field.
SEND FOR CATALOG 110A
PHILADELPHIA THERMOMETER CO.
4400 N. Sixth St. • Philadelphia 40, Pa.
Since 1905

How to analyze design, and select AUTOMATIC FEEDBACK CONTROL SYSTEMS

Here is a practical manual giving needed facts for efficient analysis, design, selection, and use of control apparatus. It covers the theory, illustrating it freely with graphical charts and curves. It discusses automatic controls and their applications, and the type of problems encountered in various engineering and industrial fields. Methods and procedures of analyzing and designing control systems are supplemented with circuit diagrams and examples of different classes of instruments which show both their functional and constructional requirements. The book includes useable data on the analysis of control reactions in multiple-loop systems; on pneumatically operated controls; regulation of temperature; design and selections of valves; nonlinear feedback controls, etc. Terminology and designing control systems are the ASME and AIEE, and are applicable to all fields without limitation.

Just Published!
AUTOMATIC FEEDBACK CONTROL
By **William R. Ahrendt**
Pres., The Ahrendt Instrument Co.
and **John F. Taplin**
Consulting Engin.; Pres., Kendall Controls Corp.
412 pp., 378 illus.; $7.50

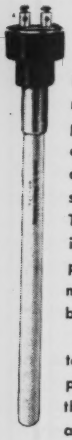
CONTENTS
1. Introduction
2. Dynamical Analysis of Physical Systems
3. The Operational Approach to Feed-Back Control
4. Frequency Spectrum Analysis
5. Feedback Control Loops
6. Multiple-loop Feedback Control Systems
7. Design Considerations
8. Nonlinearity and Discontinuity
9. Servomechanisms
10. Pneumatically Operated Controllers
11. Temperature Regulation
12. Speed Governing
13. Pressure, Flow, and Liquid Level

SEE THIS BOOK 10 DAYS FREE
Mail Coupon Today

McGraw-Hill Book Co., Inc.
330 W. 42 St., NYC 36
Send me Ahrendt & Taplin's AUTOMATIC FEEDBACK CONTROL for 10 days examination on approval. In 10 days I will send $7.50, plus few cents postage or return the book postpaid.
(Print)
Name .....
Address .....
City .....Zone.....State.....
Company .....
Position IN-1-51
This offer applies to U.S. only.

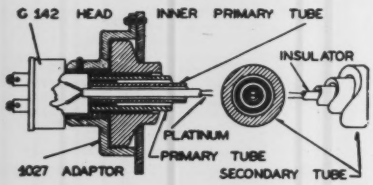
1 QUALITY
2 ACCURACY
3 CRAFTSMANSHIP

all three available in
GORDON
Platinum, Platinum-Rhodium
THERMOCOUPLES



A background of many years of experience and "know-how" go into the production of Gordon Platinum, Platinum-Rhodium Thermocouples. From this experience has evolved the Gordon policy which calls for the utmost in quality and service, the utmost in value to clients. That is why Gordon platinum wire is carefully checked for thermocouple accuracy against a master thermocouple... calibrated and certified by the National Bureau of Standards.

The porcelain insulation and protecting tubes which go into a complete thermocouple assembly are of the finest quality obtainable. They are the best known means of preventing contamination of the elements which result in false e.m.f. values. Also, the Gordon G-142 head which goes



into a complete thermocouple assembly is light in weight and permits easy replacement of new elements into a protecting tube assembly.

The Gordon Policy—highest quality and standards of material — plus Gordon craftsmanship at the lowest possible price.

Write now for full information and price list.

GORDON SERVICE

CLAUD S. GORDON CO.

Manufacturers & Distributors

Thermocouple Supplies • Industrial Furnaces & Ovens
Pyrometers & Controls • Metallurgical Testing Machines

Dept. 21 • 3000 South Wallace St., Chicago 16, Ill.
Dept. 21 • 2035 Hamilton Ave., Cleveland 14, Ohio

INSTRUMENT & CONTROL CONSULTANTS

Engineering Services, Testing Laboratories and other Professional Services

FLUID CONTROLS CO., INC.
Control Engineers
Procurement, Application, Design and Installation Supervision of control systems in Refining, Chemical, Aircraft, Paper, Power and associated industries.
NEW YORK PHILADELPHIA (28) BALTIMORE

ENGINEERING DIVISION
M. S. JACOBS & ASSOCIATES, INC.
APPLICATION & ENGINEERING OF INDUSTRIAL PROCESS CONTROLS SPECIALIZING IN THE STEEL & CHEMICAL INDUSTRIES.
810 NOBLESTOWN ROAD • CARNEGIE, PA.
TELEPHONE (Pittsburgh, Pa.) Walnut 1-6140

Your card as per above in 12 issues of INSTRUMENTS for $100, payable in advance.

Manufacturers' New Literature

In this department we report new literature, pertaining to instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on Page 113.

Requests for literature FROM ABROAD should be made on company letterhead and mailed DIRECTLY to the manufacturers.

Temperature

U-1 **Pyrometer Supplies.** 44-page Buyers' Guide No. 100-4 covers maker's large line of thermocouple assemblies and components. Includes selection data for various applications.—Industrial Div., Minneapolis-Honeywell Regulator Co., Wayne & Roberts Ave., Phila. 44, Penna.

U-2 **Temperature-control System.** 4-page Bulletin F-4869 describes new "Micropulse" temperature-control system, including response and pulse characteristics, and components of system.—Barber-Colman Co., Aircraft Div., Rockford, Ill.

Pressure

U-3 **Low-pressure Cells.** 2-page Bulletin 326 presents "Baldwin SR-4" low-pressure cells of 0-10 to 0-100 psi. capacity for measuring variations in gas or liquid pressures. Includes wiring diagram and specifications.—Baldwin-Lima-Hamilton Corp., Phila. 42, Penna.

U-4 **Vacuum Gages.** 30-page Vol. 2 No. 1 issue of "The Welch Physics and Chemistry Digest" features digests of scientific articles. Also description of vacuum gages, steel balances, electric stirrer and grating spectrometer.—W. M. Welch Scientific Co., 1515 Sedgwick St., Chicago 10, Ill.

U-5 **Air Pump.** 2-page issue of the "Leiman Leaflet" illustrates and describes maker's air pumps for pressure and vacuum, including features and applications.—Leiman Bros., Inc., 146 Christie St., Newark 5, N. J.

U-6 **Vapor-pump Fluids.** 4-page Brochure gives properties and applications of maker's line of vapor-pump fluids for use in high-vacuum equipment.—Distillation Products Industries, Rochester 3, N. Y.

U-7 **Diffusion Pump.** 8-page brochure illustrates and describes "Type MCF" diffusion pumps. Includes principles, applications, specification table, and operating characteristics.—Distillation Products Industries, Rochester 3, N. Y.

Flow

U-8 **Flowmeters.** 38-page Bulletin 460 illustrates and describes maker's large line of flowmeters, including principles of measurement, piping, recorders, controllers, indicators, pneumatic transmission, integrators, mercuryless flowmeters, and seals.—The Foxboro Co., Foxboro, Mass.

U-9 **Pumps and Meters.** 4-page Vol. 3 No. 2 issue of "SK Engineering News" features application of maker's pumps, jet eductors, and rotameters.—Schutte and Koerting Co., Cornwells Heights, Bucks County, Penna.

Steam, Water Level, etc.

U-10 **Non-frosting Level Gages.** 2-page brochure illustrates and describes maker's non-frosting level gages, both reflex and transparent.—Jerguson Gage & Valve Co., 80 Fellsway, Somerville 45, Mass.

U-11 **Float Valves.** 2-page Bulletin L-100 illustrates and describes maker's "No. 18 Series" float valves for level control.—McDonnell & Miller, Inc., 3500 N. Spaulding Ave., Chicago 18, Ill.

Radioactivity

U-12 **Radiation Instruments.** 12-page illustrated price list shows scalers, nucleometers, rate meters, counters,

taking a helicopter's pulse — to avoid future trouble

Helicopters, especially those of radical design, pose many flight-test measurement problems. To gather complete data of their new MC-4, McCulloch Motors, Aircraft Division, installed a Consolidated 5-114 Recording Oscillograph and Bridge Balance alongside the pilot to record as many as 18 data channels *simultaneously*.

Control positions, rotor RPM, blade pitch, blade and supporting-arm strains, accelerations —all were recorded simultaneously in exact relationship to one another giving the engineers a *complete*, permanently recorded picture of overall performance during every possible flight maneuver.

consolidated
recording oscillograph

The 5-114 Recording Oscillograph is used for multichannel testing of hundreds of widely varying products from trains to rocket-propelled planes, from small valves to entire oil-drilling derricks. Write for Bulletin CEC-1500.

consolidated engineering *corporation*

Analytical Instruments for Science and Industry
300 No. Sierra Madre Villa
Pasadena 8, California

Giannini makes them

FREE • VERTICAL • DIRECTIONAL • RATE

Write us about your gyro problems, both A. C. and D. C.

G. M. GIANNINI & CO., INC.
Pasadena 1, California

Giannini

Engrave
. . . PANELS UP TO 25" WIDE
IN YOUR OWN SHOP WITH THE
NEW ENGRAVOGRAPH
Portable Model 1-S

Send for Booklets
I-S-37 portable model
H-37 heavy duty model

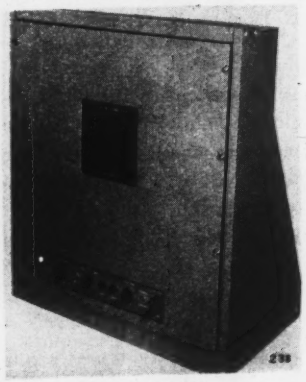
The only portable machine which reproduces 15 sizes from one master alphabet.

The only one with adjustable copy holding slides for multiline engraving in one set-up.

Self-centering holding vise for nameplates.

NEW HERMES, Inc.
13-19 University Place New York 3, N.Y.

COUNTING
Problems Eliminated With The Versatile Walkirt
EVENTOMETER
Precision Counting to Over 150 KC.



We Stock A Complete Line
PLUG-IN UNITS

Including over 30 individually packaged binary and linear scalers, amplifiers, pulse generators, gates, triggers, multivibrators, oscillators, and associated units, the use of which provide substantial savings in engineering, production and maintenance.

Representatives Territory Open

The WALKIRT Co.
1508 MARILYN AVE., DEPT. I
CULVER CITY, CALIF.

NEW LITERATURE

shields, absorbers, and other instruments for radioactivity measurements.—Radiation Counter Laboratories, Inc., 1844 W. 21st St., Chicago 8, Ill.

U-13 **Radiation Instruments.** Set of 2-page illustrated bulletins covers features, construction, and performance of maker's isotope analysis unit, pocket chambers, dosimeters, and charger.—Landsverk Electrometer Co., 140 W. Providencia Ave., Burbank, Calif.

U-14 **Contamination Monitor.** 2-page brochure illustrates and describes new "Model D-3 Alpha Survey Meter" for monitoring flat or irregular surfaces. Includes features and specifications.—Radioactive Products, Inc., 443 W. Congress, Detroit 26, Mich.

U-15 **Beta Gages.** 12-page illustrated Booklet 8-51-5M covers principles, features, application, and specifications of maker's "BG-1" absorption and backscatter beta gages.—Tracerlab, Inc., 130 High St., Boston 10, Mass.

Combustion

U-16 **Smoke Indicators.** 4-page illustrated Bulletin 5101 covers maker's line of visual smoke and combustion indicators, consisting of light, mirrors, and lenses. Includes features, operation, and installation.—Ess Specialty Corp., 96 S. Washington Ave., Bergenfield, N. J.

U-17 **Smoke Recorder.** 2-page Bulletin 512 illustrates and describes maker's photoelectric-type smoke recorder. Includes features and specifications.—Ess Instrument Co., 96 S. Washington Ave., Bergenfield, N. J.

U-18 **Combustion Control.** 4-page Bulletin 802 illustrates and describes "Hazegage" electric-eye smoke-alarm and combustion indicator. Includes features and applications.—Ess Instrument Co., Bergenfield, N. J.

Vibration & Acceleration

U-19 **Vibration Analysis.** 16-page brochure illustrates and describes maker's "Vibration Discriminator" which analyzes vibration. Includes principles, features, and applications.—Lion Mfg. Co., Inc., Columbus, Ohio.

U-20 **Transducers.** 8-page Bulletin CEC-1503 illustrates and describes maker's line of pickups for vibration and acceleration. Includes principles, features, applications, and selection data.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 8, Calif.

U-21 **Accelerometers.** 8-page Bulletin 4.0 covers line of linear accelerometers, including specifications and selection data.—Statham Laboratories, 12401 W. Olympic Blvd., Los Angeles 64, Calif.

U-22 **Rotary Accelerators.** 4-page Specification Sheet E-1-1 illustrates and describes "Models M-6, G-50, and P-100" accelerators for rotation testing. Includes features and table of specifications.—Schaevitz Engineering, Camden, N. J.

Speed & Timing

U-23 **Impulse Counter.** 1-page illustrated Bulletin GEC-829 describes features and specifications of new step-motor impulse counter for rates from 0 to 60 counts per sec.—General Electric, Schenectady, N. Y.

U-24 **Speed Indicator.** 4-page illustrated Bulletin 735 describes "Jaquet" chronometric-type speed indicators, including features and specifications.—Herman H. Sticht Co., Inc., 27 Park Pl., New York, N. Y.

U-25 **Time-delay Relays.** 12-page Bulletin T-2 illustrates and describes line of accurate "Tarrytron Time Delays," including specifications.—Cook Electric Co., 2700 N. Southport Ave., Chicago 14, Ill.

U-26 **Timers.** 2-page Bulletin 751 illustrates and describes maker's clocks and interval timers, including features and prices.—The Tork Clock Co., Inc., Mt. Vernon, N. Y.

Valves & Tubing

U-27 **4-way Valves.** 4-page Bulletin 1046 illustrates and describes maker's pilot-operated solenoid-controlled 4-way valves. Includes principles, specifications, and prices.—Barksdale Valves, 1566 E. Slauson Ave., Los Angeles 11, Calif.

U-28 **Relief Valves.** 4-page catalog illustrates and describes maker's large line of air, gas, steam, and liquid safety and relief valves. Includes service recommendations.—Kunkle Valve Co., 119 S. Clinton St., Fort Wayne, Ind.

U-29 **Valve Lubrication.** 4-page article reprint "Proper Valve Lubrication" discusses importance, function, selection, and application of various types of valve lubricants in general use.—Brown Instruments Div., Minneapolis-Honeywell Regulator Co., Station 40, Wayne & Windrim Ave., Phila. 44, Penna.

U-30 **Instrument Lines.** 8-page brochure illustrates and describes features, properties, and application of aluminum instrument lines.—Aluminum Company of America, Pittsburgh 19, Penna.

U-31 **Nonflammable Hydraulic Fluid.** 12-page booklet describes properties and performance of "Pydraul F-9" nonflammable, noncorrosive, stable, and nonvolatile hydraulic fluid with high lubricity and pumpability.—Monsanto Chemical Co., St. Louis 4, Mo.

Optical

U-32 **Periscope Optics.** 8-page issue of "The Perkin-Elmer Instrument News" features articles on periscope optics, on use of infrared spectroscopy, and on electrophoresis.—The Perkin-Elmer Corp., Norwalk, Conn.

U-33 **Polarization.** 4-page Bulletin F 969 contains "Primer of Polarization" and list of references on polarized light.—Polaroid Corp., Dept. TF, Cambridge 39, Mass.

U-34 **Color-harmony Manual.** 8-page folder illustrates and describes maker's color manual, which is a collection of 943 plastic chips with separate color and notation.—Color Standards Dept., Container Corp. of America, 38 S. Dearborn St., Chicago 3, Ill.

U-35 **Ceiling Outlets.** 20-page illustrated Catalog AIA File 30E covers maker's new line of "Venturi-Flo-Lite" outlets which combine air distribution and interior lighting. Also large line of air-distribution outlets.—Barber-Colman Co., Rockford, Ill.

Chemical Laboratory

U-36 **Gel-time Meter.** 2-page Bulletin GEC-820 illustrates and describes new gel-time meter which identifies gelatin points of thermosetting compo-

Lapp

AUTO-PNEUMATIC

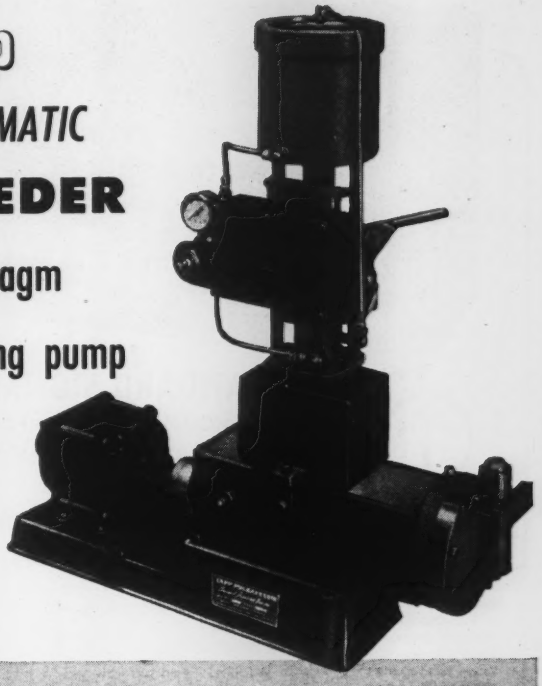
PULSAFEEDER

piston-diaphragm

chemical metering pump

with automatic

output control



For automatic metered pumping of corrosive or "hard-to-handle" chemicals, the Lapp Auto-Pneumatic Pulsafeeder offers new accuracy, efficiency and dependability. Applicable to all pneumatic or electro-pneumatic instrumentation, the Auto-Pneumatic Pulsafeeder provides automatic metering in response to variable flow, pH, temperature, liquid level, pressure, or other processing variables. The Pulsafeeder accomplishes this with a pump that operates at a constant pumping speed; variable flow results from variation only in piston stroke length, controlled by the pneumatic cylinder. In addition, through a manual ratio control, means is provided for accurate adjustment of output rate independent of instrument air pressure changes. And the Lapp Pulsafeeder is the positive displacement proportioning pump that operates without stuffing box or running seal. Its hydraulically-balanced diaphragm acts as a floating partition which isolates the chemical being pumped from pump parts—to protect against contamination of product or equipment. Entire mechanism inherently explosion-proof.

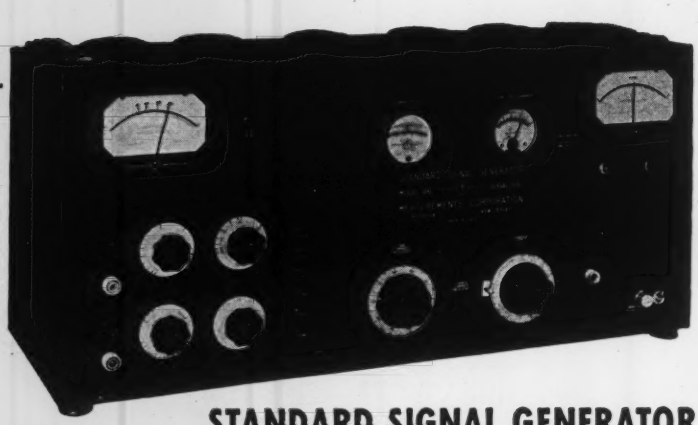
WRITE for complete description and specifications. Lapp Insulator Co., Inc., Process Equipment Division, 478 Maple St., LeRoy, N. Y.

Lapp

PROCESS EQUIPMENT

CHEMICAL PORCELAIN VALVES • PIPE • RASCHIG RINGS

PULSAFEEDER CHEMICAL PROPORTIONING PUMPS



STANDARD SIGNAL GENERATOR

MODEL 84—300-1000 Megacycles

OUTPUT VOLTAGE: Continuously variable from 0.1 to 100,000 microvolts. Output impedance, 50 ohms.

MODULATION: Sine Wave: 0-30%, 400, 1000 or 2500 cycles. Pulse: Frequency, 60 to 100,000 cycles. Width, 1 to 50 microseconds. Delay, 0 to 50 microseconds. Sync. output, up to 50 volts, either polarity.

POWER SUPPLY: 117 volts, 60 cycles. (Also available for 117 volts, 50 cycles; 220 volts, 60 cycles; 220 volts, 50 cycles.)

DIMENSIONS: 12" high x 26" wide x 10" deep, overall.

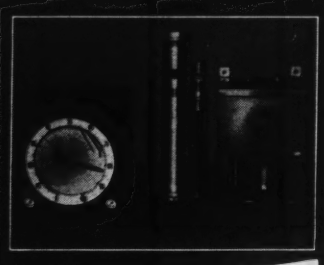
WEIGHT: Approximately 135 pounds, including external line voltage regulator.

Laboratory Standards

MANUFACTURERS OF
Standard Signal Generators
Pulse Generators
FM Signal Generators
Square Wave Generators
Vacuum Tube Voltmeters
UHF Radio Noise & Field Strength Meters
L-C-R Bridges
Megohm Meters
Megacycle Meters
Intermodulation Meters
TV & FM Test Equipment

MEASUREMENTS CORPORATION

BOONTON · NEW JERSEY



GAGETRON Applied to Measurement of Catalyst Level

New industrial application of atomic energy employs radium and hydrogen tube. Catalyst level is measured by number of atomic impulses passing through the counter tube. The primary element is the GAGETRON.

The GAGETRON is manufactured under Graham Patent No. 2,565,963.

FREE! Safety Code for use of radium. Also GAGETRON Bulletin No. 149.

INSTRUMENTS, INC.

122 N. Madison · Tulsa 6, Okla.

HARDNESS TESTING...

done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 42 years.

In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

Illustrated bulletins free

The Shore Instrument & Mfg. Co., Inc.

90-35 Van Wyck Expressway
Jamaica 2, N. Y.

NEW LITERATURE

sitions. Includes features and specifications.—General Electric, Schenectady, N. Y.

U-37 **Indicator Solutions and Reagents.** 4-page Catalog 600-20 lists 18 indicator solutions and reagents for pH measurements, water and chemical analyses with Hellige Simplex Testers, Comparators, and Aqua Testers employing non-fading glass color standards.—Hellige, Inc., 3718 Northern Blvd., Long Island City, N. Y.

U-38 **Pressure Reaction Apparatus.** 6-page Specification 4500 illustrates and describes "Series 4500" reaction apparatus for hydrogenation and chemical reactions at high pressures and temperatures.—Parr Instrument Co., 211 53rd St., Moline, Ill.

U-39 **Teflon-coated Ground-glass Joints.** 60-page 14th edition of "What's New for the Laboratory" features descriptions of Teflon-coated ground-glass joints, pipettes, absorption cells, self-pumping stills, pH meter, and others.—Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.

U-40 **Acid Pail.** 4-page Bulletin 540 describes blow torches, stop watches, synthetic-rubber pails for acids, and other laboratory devices.—Andrew Technical Service, 3805 N. Clark St., Chicago, Ill.

Chemical Process Analysis

U-41 **pH Indicator.** 8-page Vol. 11 No. 3 issue of "Modern Precision" features articles on line-operated pH indicator which is accurate to 0.02 pH. Other articles are on furnace temperature control, carbon-concentration control, stream-pollution control, generator load control, and power-level recorder.—Leeds & Northrup Co., 4907 Stenton Ave., Philadelphia 44, Penna.

U-42 **Mass Spectrometers.** 12-page Vol. 5 No. 4 issue of "CEC Recordings" features articles on mass spectrometer design and applications, on multichannel oscillography, and on thermal converter for recording power output by galvanometer.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 8, Calif.

U-43 **Chemical Spectroscopy.** 20-page No. 51-10-44 issue of "Eberbach Announcer" features article on chemical spectroscopy, on "Burrell Carbotrane," on "Coleman Autotrator," and others.—Eberbach & Son Co., Ann Arbor, Mich.

Inspection and Testing

U-44 **Reflectoscope Camera.** 2-page illustrated Bulletin 50-120 covers features and application of camera attachment for maker's ultrasonic "Reflectoscope."—Sperry Products, Inc., Danbury, Conn.

U-45 **Inspection Service.** 8-page Bulletin 50-115 illustrates and describes commercial inspection and testing service conducted by engineers trained in use of ultrasonic "Reflectoscope" and "Reflectogage."—Sperry Products, Inc., Danbury, Conn.

U-46 **X-ray Equipment.** 14-page folder illustrates and describes large line of industrial X-ray equipment, including betatron and accessories.—Picker X-Ray Corp., 25 S. Broadway, White Plains, N. Y.

U-47 **Shock Testing.** 1-page bulletin illustrates and describes maker's "Model TM-B" shock-testing mechanism for testing between 40 and 100 G.—Haines Designed Products Corp., 117 N. Findlay St., Dayton 3, Ohio.

U-48 **Production Gage.** 4-page Bulletin 103-11-51-5 illustrates and describes "Par-Ac" electronic gage for gaging to less than 0.00001 in. Includes features, components, and specifications.—Graham-Mintel Instrument Co., 735 Carnegie Ave., Cleveland 15, Ohio.

Remote Positioning

U-49 **Remote Position Control.** 4-page Bulletin 20-106 describes principles, operation, and features of hydraulic remote-positioning control systems.—Sperry Products, Inc., Danbury, Conn.

U-50 **Flexible Controls.** 7-page Catalog 1551 illustrates and describes maker's line of flexible push-pull controls of compression and tension types. Includes specifications and installation data.—Southwest Products Co., 10 S. Catalina Ave., Pasadena 1, Calif.

Electrical and Electronic Instruments

U-51 **Test Instruments.** 84-page 1952 Catalog GEC-1016 covers maker's complete line of testing and measuring instruments, including d-c. amplifiers, electronic test equipment, timers, materials testing and inspection equipment, chemical analysis equipment, thickness gages, leak detectors, power supplies, and others.—General Electric Co., Schenectady, N. Y.

U-52 **Electronic Instruments.** 4-page Vol. 7 No. 2 issue of "Allied News" describes electronic instruments handled by distributor, including new "RCA Sweep Generator WR-40A," "Intrud-alarm" capacity-operated warning device, and "Brush" headphones.—Allied Radio, 833 W. Jackson Blvd., Chicago 7, Ill.

U-53 **Electronic Instruments.** 16-page Supplement No. 128 illustrates and describes new TV and radio releases, including kits for oscilloscope, tube tester, and signal generator.—Allied Radio, 833 W. Jackson Blvd., Chicago 7, Ill.

U-54 **Densitometers.** 20-page Technical Information Bulletin 250 illustrates and describes new line of electronic transmission and reflection densitometers. Includes principles, applications, and operations.—Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

U-55 **Battery Tester.** 2-page illustrated Bulletin A-52 describes maker's new "Battery-scope" which quickly analyzes both condition and state of charge of storage batteries.—McColpin-Christie Corp., Ltd., Los Angeles 43, Calif.

U-56 **Oscillography.** 16-page Vol. 12 No. 4 issue of "The Oscillographer" contains articles on phosphors, cathode-ray tubes, and transient response. Includes table of phosphor characteristics.—Allen B. Du Mont Laboratories, Inc., Instrument Div., 1000 Main Ave., Clifton, N. J.

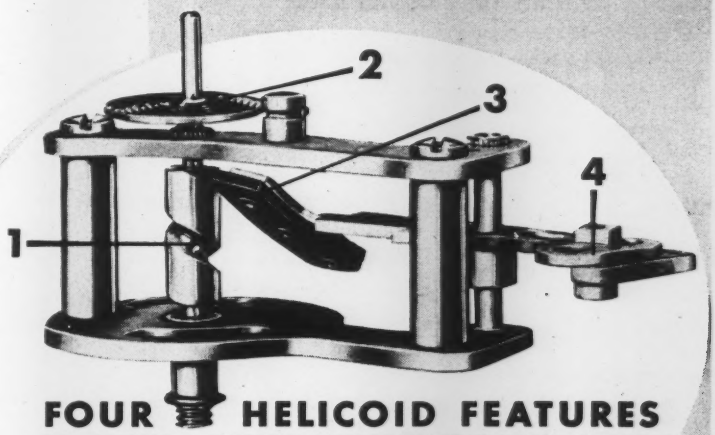
U-57 **Oscillographs and Amplifiers.** 4-page Bulletin 7-51 illustrates and describes single-channel and multi-channel oscillographs; also dual-channel a-c. and d-c. amplifier. Includes features and

an ACCO product

HELICOID

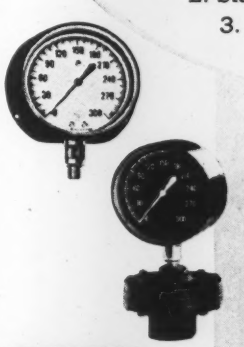
The gage that retains its original accuracy longer, wears longer, costs less per gage, per year

The greatest achievement of the gage makers' craft—pressure gages without gears. The Helicoid movement... tested and proved in years of hard service... is a simple cam and roller arrangement that gives long, trouble-free service.



FOUR HELICOID FEATURES

1. Stainless Steel Helicoid Roller (no gear teeth)
2. Stainless steel hair spring
3. Long Life Cam (no gear teeth)
4. Monel link and screws



• HELICOID GAGES, which do not have gear teeth to wear out, are made in a full range of pressures...in various sizes and shapes, with black, white and radiant faces. For wall or stem mounting, flush or panel mounting, or flangeless. No finer gages are made. Helicoid Gages cost less in the long run.

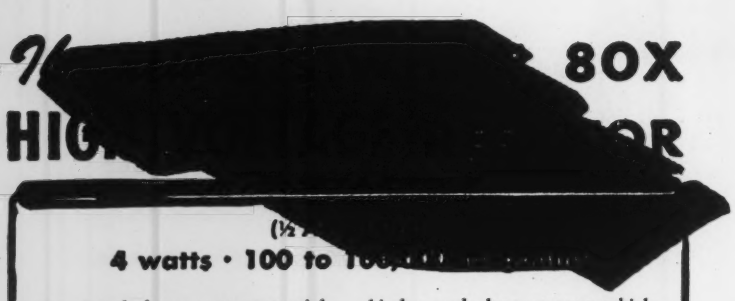
Write today for the Helicoid Gage catalog.

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE

925 Connecticut Avenue • Bridgeport 2, Connecticut

HELICOID Pressure • Vacuum GAGES



4 watts • 100 to

Developed for use as potential dividers in high voltage electrostatic generators, S.S.White 80X Resistors have many characteristics—particularly negative temperature and voltage coefficients—which make them suitable for other high voltage applications.

They are constructed of a mixture of conducting material and binder made by a process which assures adequate mechanical strength and durability. This material is non-hygroscopic and, therefore, moisture - resistant. The resistors are also coated with General Electric Dri-film which further protects them against humidity and also stabilizes the resistors.

WRITE FOR BULLETIN 4906

It gives complete information on S.S.White resistors. A free copy and price list will be sent on request.

THE S.S.White INDUSTRIAL DIVISION
DENTAL MFG. CO.
Dept. I, 10 East 40th St.
NEW YORK 16, N. Y.

WESTERN DISTRICT OFFICE: Times Building, Long Beach, Calif.

CLEANING?

Don't tear down your instruments!

The ENG-SOL Method of Precision Parts cleaning now makes it possible to whisk away fingerprints, oil, grease, dirt, lapping compounds, abrasives, lint, or other contamination.

Our bulletin "Precision Cleaning" describes this new high-velocity compressed air method of cleaning.

Send for it—today.

PASSAIC ANALYTICAL LABORATORIES, Inc.
228 Aycrigg Ave. Passaic, N. J.

Second Edition (1951)
Now Available

Mechanical Measurements by Electrical Methods

By HOWARD C. ROBERTS

Special Research Associate Professor of Civil Engineering, University of Illinois *(for many years in Research Lab., A.R.A.)*

Typical of the comments received while this book ran as a serial in *Instruments*:

". . . I appreciate the thoroughness with which the subject is being treated." "We are sure that your articles will be widely read, for it is a subject certainly in need of the correlation you are giving it."

Cloth, 5x8¼ inches, x+357 pages
Profusely Illustrated

$4.00 postpaid
Payment must accompany order

The Instruments Publishing Co.
921 Ridge Ave., Pittsburgh 12, Pa.

NEW LITERATURE

specifications.—Rahm Instruments, Inc., 12 W. Broadway, New York 7, N. Y.

U-58 **Electronic Stethoscope.** 4-page brochure "How To Cut Costs on Equipment Maintenance" covers usage of new "Elec-Detec" electronic stethoscope in locating and analyzing mechanical troubles.—Anco Instrument Div., American Name Plate & Mfg. Co., 4254 W. Arthington St., Chicago 24, Ill.

U-59 **Voltage Regulators.** 4-page brochure illustrates and describes line of rocking-contact generator voltage regulators, including construction, features, operation, and installation.—Allis-Chalmers, Milwaukee 1, Wis.

U-60 **Engine Control.** 44-page loose-leaf Catalog 4 covers maker's large line of series control sets, automatic cranking controls, safety stops, overspeed governors, and auxiliary units. Includes engine-generator control panels.—Synchro-Start Products, Inc., 8151 N. Ridgeway Ave., Skokie, Ill.

U-61 **Bridging Amplifier.** 4-page bulletin describes "Model 102 Phantom Repeater" bridging amplifier which matches high-impedance sources to test instruments. Includes applications and features.—Keithley Instruments, 3868 Carnegie Ave., Cleveland 15, Ohio.

U-62 **UHF Sweep Generator.** 4-page Bulletin WR-40A-10-51 illustrates and describes new "WR-40A" sweep oscillator with marker and crystal calibrator. Includes block diagram and preliminary specifications.—Radio Corp. of America, Test & Measuring Equipment, Harrison, N. J.

U-63 **Fault Locator.** 4-page bulletin describes "Model M-1-A" portable fault locator for detecting and locating high-resistance crosses and faults.—R. F. Miller & Sons, Harvard, Neb.

U-64 **Insulation Tester.** 4-page Publication ES/106 illustrates and describes new British-made high-voltage d-c. insulation tester, including features and specifications.—Herman H. Sticht Co., Inc., 27 Park Pl., New York 7, N. Y.

U-65 **Load Relays.** 2-page illustrated Form 860 describes power-relay control for 2-hp. siren, which uses mercury-plunger load relays. Includes wiring diagram.—H-B Instrument Co., 2633 Trenton Ave., Philadelphia 25, Penna.

U-66 **D-c. Amplifier.** 4-page brochure illustrates and describes "Model 14" breaker-type d-c. amplifier with low noise level and high stability. Includes features and performance.—Liston-Becker Instrument Co., Inc., 20 Beckley Ave., Stamford, Conn.

U-67 **Amplifiers and Frequency Discriminator.** 1-page bulletins describe (1) high-gain 10-cps. amplifier for use with chopper and low-level inputs, (2) higher-frequency a-c. amplifiers with any desired bandwidth below 100 kc., and (3) subcarrier frequency discriminator for use at center frequency from 400 cps. to 70 kc.—Electro-Mechanical Research, Inc., Ridgefield, Conn.

U-68 **Lie Detector.** 12-page Bulletin 131 illustrates and describes maker's "Polygraph," or lie detector, with dry hand electrodes. Includes technique, equipment, and specifications.—Associated Research, Inc., 3758 W. Belmont Ave., Chicago 18, Ill.

U-69 **Variacs.** 8-page bulletin (Form 424-L) illustrates and describes maker's large line of "Variac" variable auto-

transformers. Includes features, specifications, and selection table.—General Radio Co., Cambridge 39, Mass.

U-70 **Power Supplies.** 2-page bulletin illustrates and describes "600 Series" of multiple-output regulated d-c. power supplies.—Bristol Engineering Corp., Lincoln Ave. & Pond St., Bristol, Penna.

U-71 **Power-supply Panels.** 4-page brochure illustrates and describes maker's science and laboratory control panels which supply various voltages.—Electrosig Corp., 71 Campus Dr., Buffalo 21, N. Y.

U-72 **TV Interference.** 86-page booklet is collection of articles by Mr. P. S. Rand, giving results of extensive research on TV interference caused by r-f. induction heating, transmitting stations, diathermy, etc.—Remington Rand Laboratory, Wilson Ave., S. Norwalk, Conn.

Electrical and Electronic Components

U-73 **Electronic Components.** 12-page Vol. 18 No. 12 issue of "Sylvania News" features article on a low-noise r-f. amplifier for TV.—Sylvania Electric Products, Inc., P.O. Box 431, Emporium, Penna.

U-74 **Electronic Components.** Handy pocket book contains 56-page 1952 diary, 16 pages of maps, and tube and battery data. Includes tube selection guide and components directory.—RCA Tube Dept., Harrison, N. J.

U-75 **Resistors.** 16-page Bulletin 99 illustrates and describes maker's large line of vitreous-enameled resistors. Includes features and specifications.—Lectrohm, Inc., 5560 Northwest Highway, Chicago 30, Ill.

U-76 **Tantalytic Capacitors.** 12-page article reprint "Tantalytic Capacitors" covers principles, features, construction, and advantages of tantalytic small electrolytic capacitors. Includes chemical and electrical factors.—General Electric Co., Schenectady, N. Y.

U-77 **Precision Pot-rheostats.** Bulletins 115 and 109 illustrate and describe maker's "Model-F" and "Model-T Tinytork" single-turn precision potentiometer-rheostats. Includes features and specifications.—The Helipot Corp., S. Pasadena, Calif.

U-78 **Differential Transformers.** Eight 1-page specification sheets (A-1-1 to A-1-8) describe maker's line of linear variable differential transformers. Includes features and construction.—Schaevitz Engineering, Camden, N. J.

U-79 **Electronic Tubes.** 8-page Bulletin EC-20H illustrates and describes maker's large line of diodes, strobotrons, thyratrons, gas-pressure-measuring tubes, and selenium rectifiers. Includes characteristics.—Sylvania Electric, Emporium, Penna.

U-80 **Multi-Contact Connectors.** 46-page General Catalog B2 illustrates and describes maker's large line of multi-contact electric connectors and sockets. Includes features and specs.—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

U-81 **Connectors.** 4-page Vol. 4 No. 9 issue of "Amphenol Engineering News" features articles on use of multi-contact electric connectors in electronic instruments, solenoid drain valves, etc.—American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.

U-82 **Pilot Lights.** 16-page Form L-

when you need a

SIE

SPECIFICATIONS

Range: 1 cps to 120,000 cps

Calibration: within 1½% plus 1/10 cycle

Output circuits: 20 volts or 20 milliamps and 1 volt at 300 ohms constant impedance

Amplitude stability: Plus or minus ½ db

UNDESIRED VOLTAGES

Power Supply Noise: Less than 1 100% of output signal

Power Line Surge: Less than 1/10% of output signal

Harmonic Distortion: Less than 2 10% from 20 cps to 15,000 cps. Less than 1% at all other frequencies

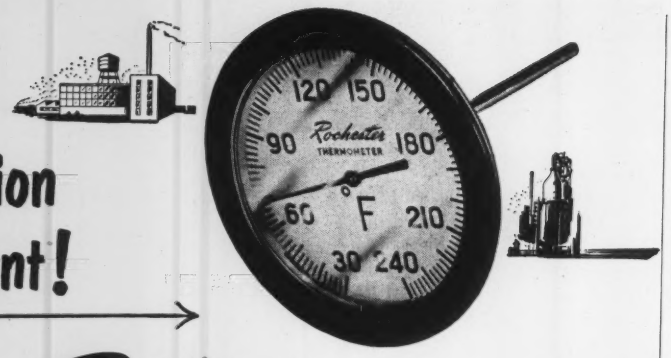
Microphonic Noise: Less than 1/100% of output signal

SOUTHWESTERN INDUSTRIAL ELECTRONICS CO.

2831 POST OAK ROAD
HOUSTON 19, TEXAS

434 SEVENTH AVE. EAST — CALGARY, ALBERTA, CANADA

More corrosion resistant!



Rochester all stainless steel thermometers permit wide range of service.

A new stainless steel welding process bonds case, stem and plug into one solid stainless steel unit. This means extra dependability under a wide range of service.

Rochester's famous bimetallic element will not *"tire"* or lose its accuracy. And a superior dampening forever eliminates pointer *"lock-up."*

Backed by 35 years of manufacturing experience, the new Rochester Dial Thermometer is your best bet for heavy-duty service.

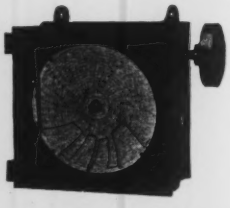
ORDER TODAY from your Rochester Representative or write Rochester Manufacturing Co., Inc., 85 Rockwood Street, Rochester 10, New York.

Rochester Manufacturing Company, Inc.
85 Rockwood St., Rochester 10, N. Y.

ROCHESTER DIMENSIONAL ACCURACY GAUGES

DIAL THERMOMETERS GAUGES AMMETERS

Amthor



Operation Speed Recorder

8" Chart
12 or 24 hr.

Built for severe service. Users report 10, 12 or more years of trouble-free life. Powerful centrifugal speed-measuring element stays calibrated. Non-spill reservoir pen. Special chart paper. Rugged clock movement. Ideal for analysis of new War Effort jobs.

Immediate and intelligent attention will be given to your inquiries on all industrial speed measurement problems. Drop us a line today.

Amthor Testing Instruments Co., Inc.
49a Van Sinderen Ave. Brooklyn, N. Y.

High Precision OPTICAL COMPONENTS Any Size For Astronomical and Physical Research

•

Parabolic, Spherical, Ellipsoidal and Plane MIRRORS

•

Plane Parallel PLATES

•

SCHLIEREN SYSTEMS

•

Interferometer PLATES

•

LENSES and PRISMS of Glass

•

Natural or Synthetic CRYSTALS

•

Complete Optical and Mechanical INSTRUMENTS

•

Made to Specifications

•

High Vacuum Coating

•

John Unertl Optical Co.

3551-3555 East Street
Pittsburgh 14, Penna.

NEW LITERATURE

151 illustrates and describes line of pilot-light assemblies, connectors, and lamp sockets.—The Dial Light Co. of America, 900 Broadway, New York 3, N. Y.

U-83 **Switches.** 2-page Oct. issue of "The Ohmite News" features description of maker's rotary tap switches, rheostats, chokes, and resistors.—Ohmite Mfg. Co., 4835 Flournoy St., Chicago 44, Ill.

U-84 **Rotary Solenoids.** 4-page Bulletin 351-RS illustrates and describes maker's line of rotary solenoids which use a solenoid to produce a rotary motion. Includes specifications and applications.—G. H. Leland, Inc., Dayton 2, Ohio.

U-85 **Relays.** 12-page Catalog R-10 describes complete line of "Amrecon" relays, including specifications, operating data, and selection data. Relays include hermetically sealed and overload.—American Relay & Controls, Inc., 4939 Flournoy St., Chicago, Ill.

U-86 **Push-pull Amplifier Circuit.** 8-page Vol. 26 No. 5 issue of "The General Radio Experimenter" features article on new push-pull amplifier circuit with balanced driver circuit.—General Radio Co., Cambridge, Mass.

U-87 **Self-holding Test Leads.** 6-page folder illustrates and describes maker's line of "Klipzon" and "Miniprod" connectors and shielded leads.—United Technical Laboratories, Morristown, N. J.

U-88 **Motors.** 16-page illustrated Bulletin B-4378, "Facts About Prelubricated Bearings," covers construction and advantages of pre-lubricated bearings in maker's line of motors.—Westinghouse Electric Corp., Buffalo 5, N. Y.

Mechanical Components

U-89 **Metal Products.** 24-page brochure illustrates and describes maker's facilities for research and production of metal products, including chassis holders, racks, etc.—Grant Pulley & Hardware Co., 31-85 Whitestone Pkwy., Flushing, L. I., N. Y.

U-90 **Clock Cranks.** 4-page brochure describes new instrument crank-type winder which replaces clock keys.—J. A. Campbell Co., 645 E. Wardlow Rd., Long Beach 7, Calif.

U-91 **Tools and Supplies.** 230-page illustrated Catalog 20 covers large line of tools and supplies, including bunsen burners, burs, files, micrometers, vises, cabinets, benches, oilers, rolling mills, drill presses, jewelers' lathes, etc.—William Dixon, Inc., 32 E. Kinney St., Newark, N. J.

U-92 **Beryllium Copper.** 2-page Technical Bulletins Nos. 9, 10, and 11 show applications of beryllium copper metal in retaining rings, stock-feeding mechanisms, etc.; also properties of sand castings and government specifications.—The Beryllium Corp., Reading, Penna.

U-93 **Speed Drives.** 2-page technical data sheet M1 illustrates and describes miniature combination fixed- and variable-speed drives for low-power applications.—Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.

Calendar of Important Instrumentation Events 1952

Jan. 28-Feb. 1
Institute of the Aeronautical Sciences.
20th Annual Meeting.
Astor Hotel, New York City.
For information write R. R. Dexter, Sec., 2 East 64th St., New York 21.

Jan. 29-31
American Meteorological Society.
114th National Meeting.
Roosevelt Hotel, New York City.
For information write Kenneth C. Spengler, Ex. Sec., 3 Joy St., Boston 8, Mass.

Feb. 7-8
Instrument Society of America, New York Section.
Fifth Annual Regional Conference, "Power Plant Instrumentation."
For information write Franklin B. Leslie, Sec., 8856 Commonwealth Blvd., Bellerose 6, N. Y.

Mar. 3-6
Institute of Radio Engineers.
National Convention and Exhibit.
Waldorf-Astoria Hotel and Grand Central Palace, New York City.

Mar. 5-7
Analytical Chemistry Group, Pittsburgh Section, American Chemical Society and Pittsburgh Spectroscopy Society Conference on Analytical Chemistry and Applied Spectroscopy. For information write to J. R. Churchill, P.O. Box 772, New Kensington, Penna.

April 1
New Jersey Section, ISA, Symposium "Use and Application of Control Valves." For information write L. H. Ballinger, 2371 Channing Ave., Westfield, N. J.

April 3-4
Instrument Society of America, Pittsburgh Section.
Second Annual Regional Conference, "Instrumentation for the Iron and Steel Industry."
Roosevelt Hotel, Pittsburgh.
For information write W. C. Langerman, Fisher Scientific Co., 711 Forbes St., Pittsburgh 19, Pa.

April 27-May 6
Heavy Industries Fair, Hanover, Germany. This fair includes exhibits of instruments for measurement, inspection, testing and control. For information write Deutsche Messe- und Ausstellungs-A.G., Hannover, Messegelaende, Germany.

May 1952
American Association of Spectrographers. Symposium on "Instrumental Methods of Analysis in the Non-Ferrous Industry." Contributed papers in this field are invited, write to Robert Raisig, c/o Apex Smelting Co., 2537 W. Taylor St., Chicago 12, Ill.

A supply of these cards for the asking

Is your copy of *Instruments* routed to several people?

Does your Company Librarian forbid mutilating tech mags?

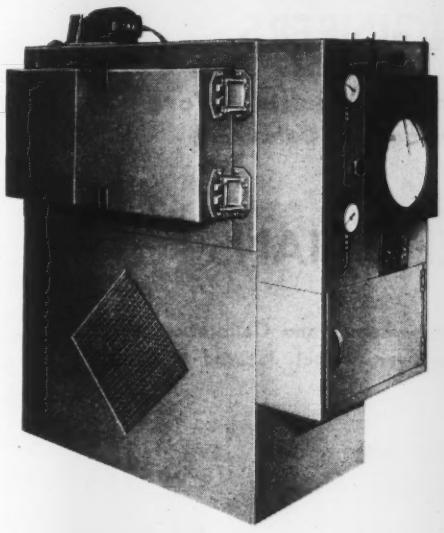
Or do you yourself wish to preserve your own copies intact?

Just drop us a postal card asking for Inquiry Cards and we'll send you twelve! Do it NOW.

May 4-8
Electrochemical Society, Fiftieth Anniversary Meeting, Benjamin Franklin Hotel, Philadelphia. Sessions on Instrumentation have been scheduled. For information write Dr. Henry Linford, Sec., 235 West 102 St., New York 25.

May 5-16
British Industries Fair. Earls Court & Olympia, London includes laboratory and scientific instru-

TEST CHAMBERS



HIGH & LOW TEMPERATURES CONTROLLED HUMIDITY

- +200°F. to —150°F.
- 20% to 95% R.H.
- 1 cu. ft. to 75 cu. ft. cabinets

Walk-in Rooms Temperature Baths

Electronic or pneumatic recording or indicating control systems

CUSTOM CHAMBERS built to specifications.

Years of satisfactory service!

52 Washington Avenue
Carlstadt, New Jersey

Standard CABINET COMPANY

ENGINEERS
MECHANICAL AND ELECTRICAL

Field Service, Design, and Estimating in the field of pneumatically and electrically operated controls.

Write to or see:

Mr. R. C. Cibella
Hagan Corporation
323 Fourth Avenue
Pittsburgh 22, Pa.

SALES ENGINEER

For long established manufacturer of flow meters and full line of air operated controls for temperature, pressure, level and flow, required for specialized field work leading to position of Sales Manager. Reply in confidence. Our organization knows of this Ad. Salary Open. A really unusual opportunity. Box 206, Instruments Publishing Co., 921 Ridge Ave., Pittsburgh 12, Pa.

Here is your LITERATURE and INFORMATION order card

Instruments, 921 Ridge Ave., Pittsburgh, Pa. *(January 1952)*

Please have the following catalogs, etc., reviewed in this issue sent to me.
Numbers .....

I desire further information on devices described in the "New Instruments" Dep't:
Numbers .....

I also desire further information concerning the following products advertised in this issue (Write page number and name of company)

Name .....
Company ..... **Position** .....
Co.'s Address .....
(OR) Home Address .....

INSTRUMENTATION ENGINEERS

for Design & Consulting Work in Wilmington, Delaware

and

TECHNICIANS

. . . for Installation, Repair and Calibration work on the Savannah River Project, located in South Carolina.

For Information

Please Write

E. I. du Pont de Nemours & Co., Inc.

Personnel Section, Engineering Dept.

WILMINGTON, DELAWARE

INSTRUMENT DEVELOPMENT ENGINEER POSITION OPEN. QUALIFICATIONS AS FOLLOWS:

1. Thorough knowledge of pressure actuated mechanical instruments and allied devices.
2. At least two years design experience on pneumatic controllers.
3. Education of, or equivalent to, graduate mechanical engineer.

MANNING, MAXWELL & MOORE, INC.
250 East Main Street
Stratford, Connecticut

"Heat Inertia" in Problems of Automatic Control of Temperature

By VICTOR BROIDA
Consulting Engineer and Process Control Specialist
PARIS, FRANCE

stiff paper, 5¼x8¼ in., 64 pages

$1.00 POSTPAID

Payment must accompany order.

Instruments Publishing Company
921 Ridge Ave., Pittsburgh 12, Pa.

FIRST CLASS PERMIT No. 1441 (Sec. 34.9 P. L. & R.) PITTSBURGH, PA.

BUSINESS REPLY CARD

NO POSTAGE STAMP NECESSARY IF MAILED IN THE UNITED STATES

4c-POSTAGE WILL BE PAID BY—

INSTRUMENTS PUBLISHING CO.

921 Ridge Avenue

Pittsburgh 12, Pa.

ments; Castle Bromwich, Birmingham, includes industrial instruments. For information write Board of Trade, Imperial Chemical House, London, S.W.1, England.

May 6-9

Scientific Apparatus Makers Association.
Annual Meeting of all Sections.
Edgewater Beach Hotel, Chicago.

May 7-9

Institute of Radio Engineers.
National Conference on Airborne Electronics.
Biltmore Hotel, Dayton, Ohio.
For information write E. K. Gannett, 1 East 79th St., New York 21.

May 16-17

Southwestern Institute of Radio Engineers.
Conference and Radio Engineering Exhibit.
Rice Hotel, Houston, Texas.

May 18-25

Achema X—Chemical Meeting and Exhibit, Frankfurt, Germany.
At the same time and place the 25th International Congress for Industrial Chemistry will be held. Instruments will be exhibited.
For information write Dr. H. Bretschneider, Deutsche Gesellschaft fuer Chemisches Apparatewisen, Frankfurt am Main 13, P.O. Box 1337, Germany.

May 22-24

American Society for Quality Control, Onondaga Memorial, Syracuse, N. Y. For information write W. R. Weaver, Gen. Chm., 1527 Republic Bldg., Cleveland 1, Ohio.

June 11-13

American Congress on Surveying and Mapping.
Twelfth Annual Meeting and Exhibit.
Shoreham Hotel, Washington, D. C.
For information write Walter S. Dix, Ex. Sec., P. O. Box 470, Benjamin Franklin Station, Washington 4, D. C.

June 23-27

ASTM 50th Anniversary Meeting and 10th Exhibit of Testing Apparatus and Laboratory Supplies, Hotel Statler, New York, N. Y. For information write Robert J. Painter, Asst. Sec., American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

Sept. 8-12

Instrument Society of America.
Seventh National Instrument Conference and Exhibit.
Public Auditorium, Cleveland, Ohio.

Sept. 29-Oct. 1

Eighth National Electronics Conference and Exhibition.
Sherman Hotel, Chicago.
For information write Karl Kramer, Ex. Sec., 852 E. 83rd St., Chicago 19.

October

Scientific Apparatus Makers Association.
Midyear Meeting of Recorder-Controller Section.
Seaview Country Club, Absecon, N. J.

Nov. 5-9

Scientific Apparatus Makers Association.
Midyear Meeting of Industrial Instrument, Laboratory Apparatus, Laboratory Equipment, Optical, Aeronautical, and Military Instruments Sections.
The Homestead, Hot Springs, Virginia.

Second Edition Available

Mechanical Measurements by Electrical Methods

By HOWARD C. ROBERTS

$4.00 postpaid

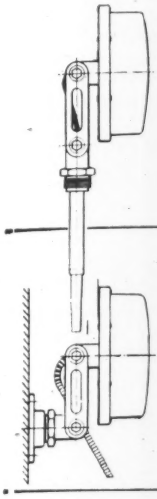
Payment must accompany order

The Instruments Publishing Co., Inc.
921 Ridge Ave. Pittsburgh, Penna.

PALMER

mercury actuated Dial Thermometers

now in three types to suit any requirements

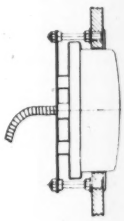


1 Rigid Stem Dial Thermometer

Rigid stem tapered bulb, interchangeable with standard industrial thermometer separable socket.

2 Wall Mounted Dial Thermometer

Wall mounted dial thermometer with flexible connecting armor. Case adjustable to easy reading position.



3 Flush Mounted Dial Thermometer

Flush mounted style for panel mounting with flexible connecting armor.

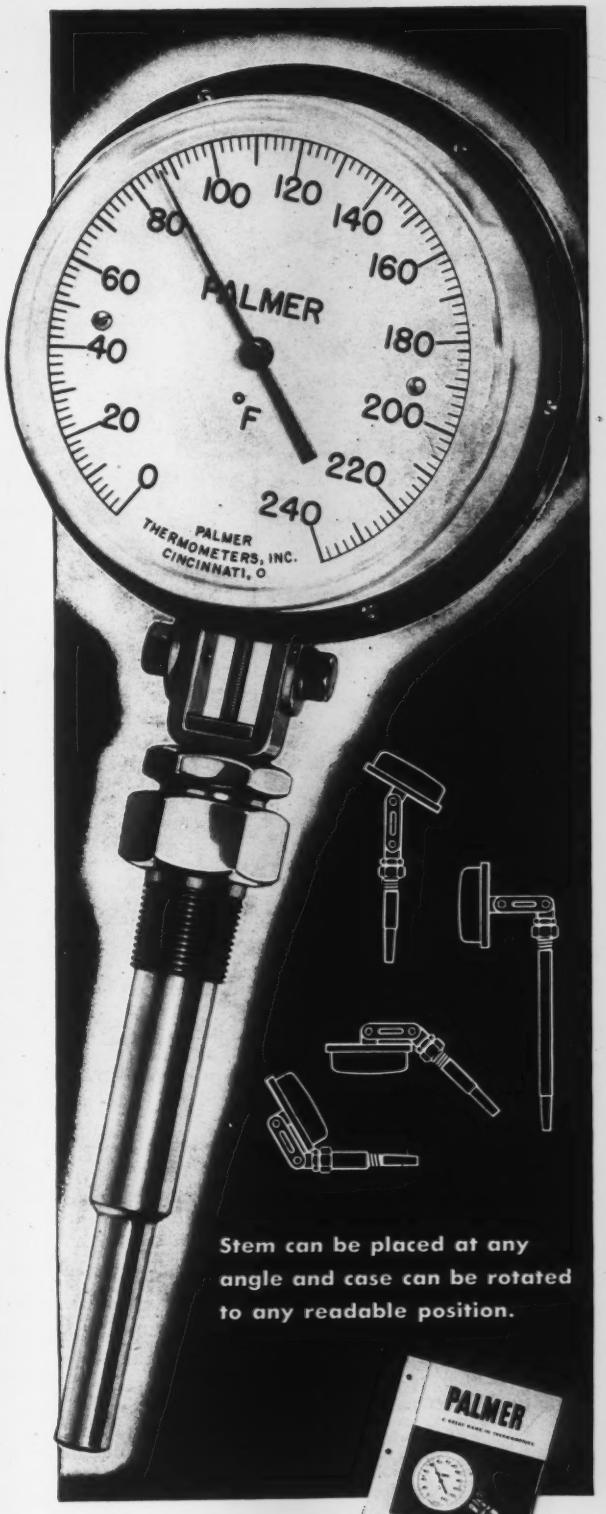
All three types have a full 4½" dial Face

for accuracy: Mercury actuated . . . Fully Compensated by Invar Compensation. Guaranteed Accurate 1 scale division.

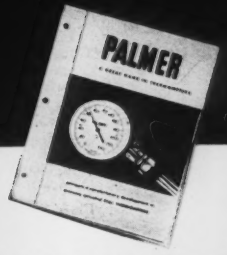
for angularity: Can be adjusted to most readable position at any angle desired.

for readability: Bold Black Numbers . . . 11" of scale Reading Dial face can always be placed in easiest readable position.

for interchangeability: Always specify "PALMER" Separable sockets as they are interchangeable for Dial or Industrial type Thermometers.



Stem can be placed at any angle and case can be rotated to any readable position.



PALMER THERMOMETERS, INC.

Mfrs. of Industrial Laboratory, Recording and Dial Thermometers

2511 NORWOOD AVE., CINCINNATI 12, O.

SEND FOR THIS BULLETIN

For details on the New Palmer Dial Thermometer, please write for Palmer Bulletin 51-129.